Tutorial case study K (Dykes)

Parent topic: User Manual and Tutorials

This case study includes:

- An introduction to building and updating a 3D geology model using 3D GeoModeller.
- A demonstration of 3D GeoModeller's dyke modelling capability.

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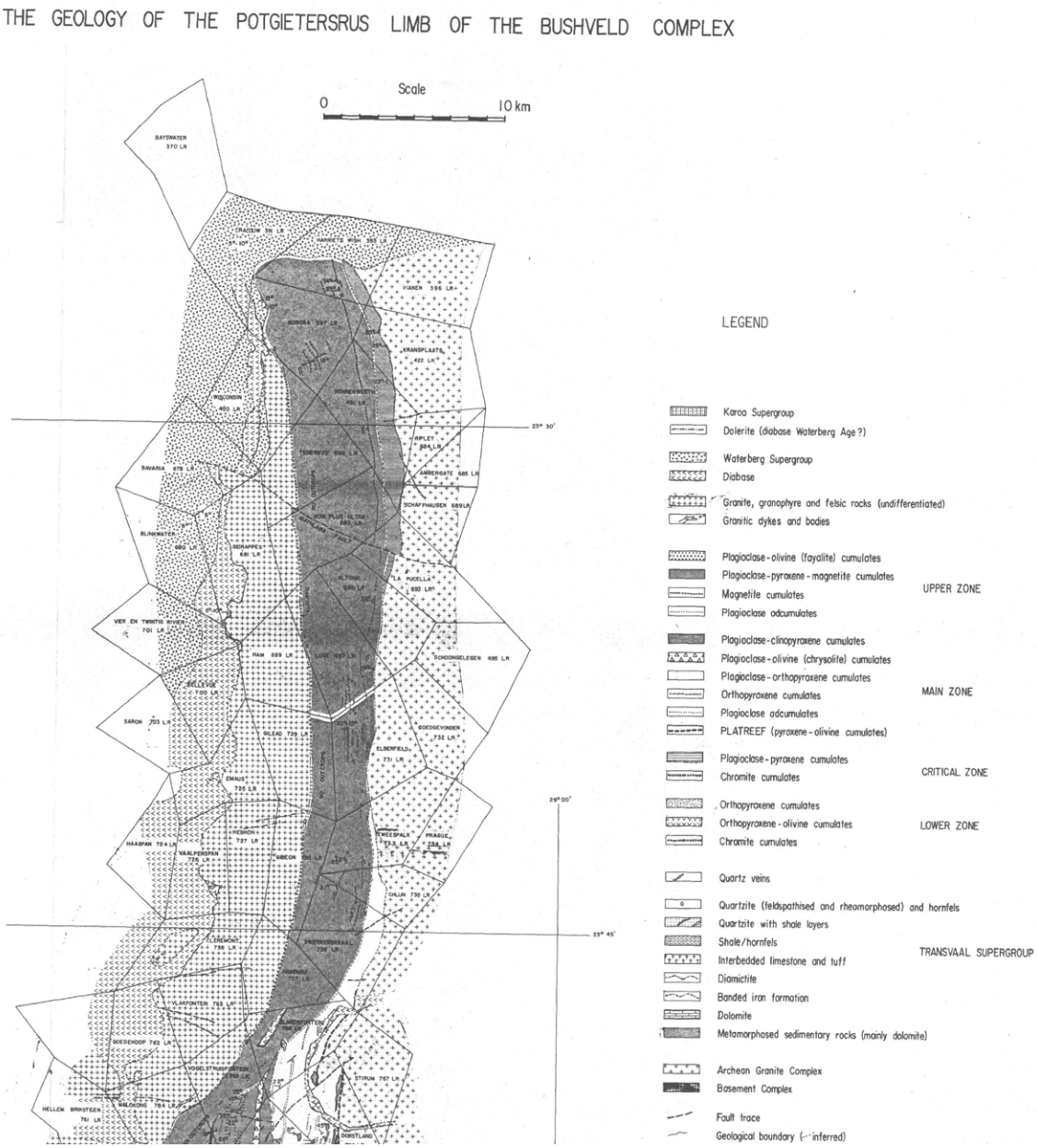

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In this case study:

- Case Study K Introduction
- Course Structure
- Tutorial K1: Create the PlatDykes 3D GeoModeller Project
- Tutorial K2: Examine then Import Project Dykes
- Tutorial K3: Update Stratigraphy Order of Dykes
- Tutorial K4: Add Geology 2—Digitise and Recompute the Model
- Tutorial K5: Import Drillhole Data and Recompute the Model

Case Study K Introduction

Parent topic: **Tutorial case study K (Dykes)**

In this case study we demonstrate the main methods available in 3D GeoModeller v2012 to rapidly create complex 3D geology involving many dykes. Dykes are assumed to mostly be observed but geologists on the topographic surface and in borehole logs. Also, a means is shown of taking an airborne magnetics survey that appears to be dominated by dyke-like bodies, and have a means of rapidly setting up a 3D geology model directly from the "automated" interpretation of "dykes" below each individual magnetics profile. For this case, the Intrepid "NAUDYD" tool is shown in a workflow. When there are more than 50 discrete dykes in a study area, it becomes quite complex to track the order in which the dykes formed, and also to date the geological events. Magnetics can help, if there is any sign of either remanent magnetizm. The prevailing magnetic azimuth and inclination at the time of emplacement of the dyke, if different from the current magnetic field vector, can be used to assist dating.

Importance of Dykes for aiding Geology Interpretation

We can do no better than quoting Henry Halls from the University of Toronto. "*My general field of research is the application of geophysical methods (gravity, magnetics and paleomagnetism) to the solution of geological problems, mainly involving major tectonic units of the Canadian shield. More recently, I have concentrated on the integrated paleomagnetic, geochronological and geochemical study of Precambrian dyke swarms worldwide in an effort to understand their origins and their use as links between dispersed Precambrian terranes.*"

The last 10 years has seen a burgeoning of papers on dykes and particularly on the recognition of "giant radiating dyke swarms". Heat plums can be a factor here.

Dykes as barriers to subsurface groundwater flow

The recognition of dykes acting as fluid barriers has importance in relation to water supply, mineral deposition, induced seismicity and to failure planes related to major volcanic landslides.

Dykes project scenario

An interpretation of the dykes is required to assist forward planning for mining in the context of a Platinum reef operation. In this case, dykes disrupt the mining process. A magnetics geophysical survey shows the presence of many granite and dolerite dykes, some or which appear to have reverse magnetization. The dolerite dykes are quite extensive while the earlier Archean granite dykes are shorter and have more variability in their shape. The mine is located somewhere near Pretoria, in the Bushveld complex, with terrain relief of over 300 meters in the project area. This is close to a real setting, but all the dyke data is fabricated for this study. There are

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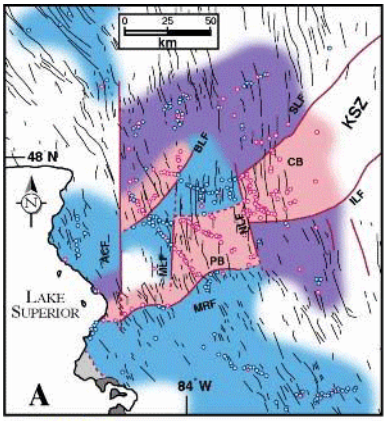
around 7 dolerite dykes all mapped on the surface and one also logged in a borehole. The geology map shown is from a 1978 hand drawn exploration map of the general area. Subsequently, several producing mines have been established and each of them is highly profitable. The project box is 20km x 30 km x 5 km.

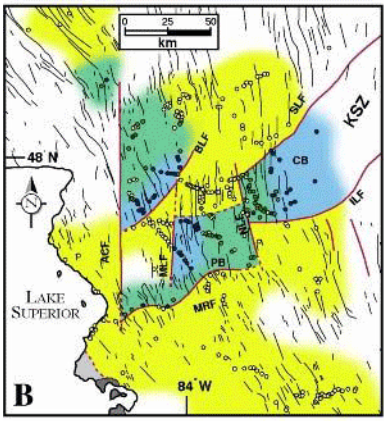
The aim of the exercise is to reconcile a 3D geological interpretation of the dykes with the magnetic survey as an aid for the mine planners.

The interpretation below is illustrative of how dyke magnetization studies can help sort out major tectonic shifts in your geology and their timings.(ref.Henry Halls)



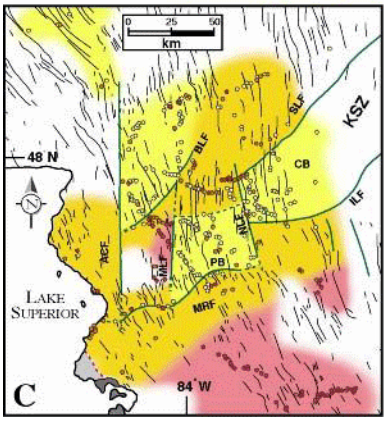
Maps showing variation in Matachewan dykes of (A) magnetic polarity, (B) feldspar clouding and (C) feldspar deuteric alteration .

A: Blue/red dots are dykes having R/N polarity; red areas are uplifted crust where dykes have N polarity; blue areas represent shallower crust where dykes are mainly R; purple areas represent intermediate level crust characterised by approximately equal numbers of R and N dykes.



B: Blue/green/yellow dots refer to dykes with pronounced/slight/zero clouding of their feldspars.

Corresponding background colours are areas characterised by these dykes.



C: Yellow/orange/red dots refer to dykes with fresh/moderately fresh/highly altered plagioclase.

Background colours of yellow/orange/red are the corresponding areas of crust that are characterized by the three classes of dykes (from Halls & Zhang 2003)

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Course Structure

Parent topic: Tutorial case study K (Dykes)

This case study has two main sections:

- Build and Revise a 3D Geology Model
- Perform Geophysical Modelling

Build and Revise a 3D Geology Model

Parent topic: Course Structure

Tutorial K1: Create the PlatDykes 3D GeoModeller Project

We create a new project, define a 3D project box and import the DTM (digital terrain model).

Tutorial K2: Examine then Import the Project Mapped dykes

We first examine the surface mapped dykes for the project, and create the project's stratigraphic pile. Compute the dyke network. Plot the dyke model in map and section views in the **2D Viewer**. Build the 3D shapes of the dyke model and examine in the **3D Viewer**.

Tutorial K3: Adjust the dyke Stratigraphy

We want to change the stratigraphic order of the dyke intrusives. We update the stratigraphic pile.

Tutorial K4: Add interpretive dyke points —Digitise and Recompute the Model

We can now digitise on the topography section, points that allow dykes to vary their thickness, and build a revised 3D geology model. And again examine the 3D geology model in 2D and 3D views. There are some conventions that need to be followed.

Tutorial K5: Import Drillhole Data and Recompute the Model

We import data for a drillhole. We create a vertical section, and project the drillhole geology onto this vertical cross-section. Note the inconsistency between the new data and the existing 3D model. We then recompute the dyke model and note the adjustment to the dyke geometry. Again examine the 3D geology model in 2D and 3D views.

Perform Geophysical Modelling

Parent topic: Course Structure

Tutorial K6: Review/Adjust the Magnetics Physical Property Data

We now add/adjust Magnetics physical property data for each dyke unit—the susceptibility, the magnetic declination and inclination.

Tutorial K7: Compute Magnetics Solutions

There are 3 strategies for computing the magnetic solutions:

The original 'hot spot' bodies that may come from airborne profile data, can have local approximations of the dyke geometry computed as prisms. In this case, the strike, length, depth, thickness are constant at each 'hot spot'. Within Geomodeller, the option to use the Dykes specified as linked lists of "Hot-spot" bodies, is provided as a quick means of assessing the forward geophysical response. The "task" file to spawn the process is created automatically and a grid that contains the result, is available after completion, to be inspected in the topography section.

In a similar manner, the second option involves using an Intrepid Database conatining the Naudy body solutions, but not sorted into a form that you have reviewed.

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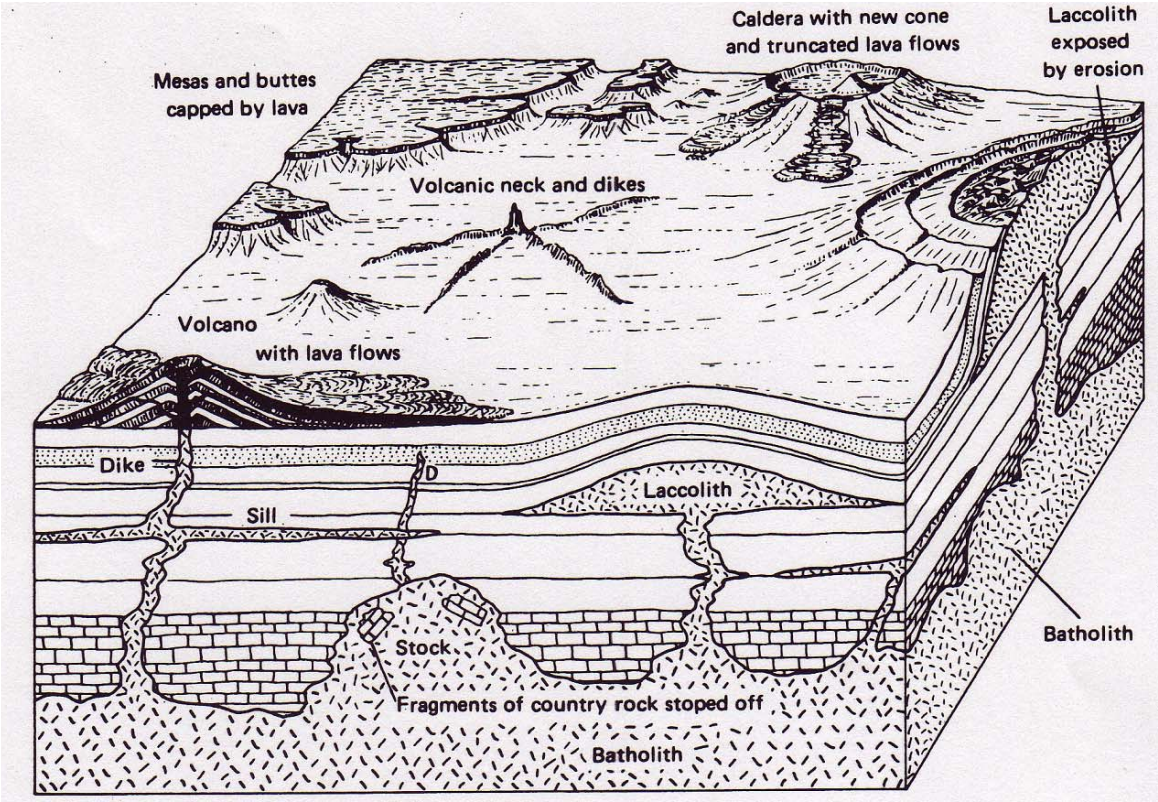
The third method involves a 3D realization of the dyke network being skeletonized, by means of each dyke being represented as a triangulated curved, semi-planar mesh. Each triangle has a thickness, susceptibility attributes and the infintely thin facet code is used to compute the magnetic response.

This function is handled outside the main 3D GeoModeller tool. The Intrepid "MTDyke" tool perfoms the actual modelling, using any of the methods for specifying a dyke model.

There are options to control the cell size and choice of algorithm for dyke calculations.



To illustate some of the complexity where we should attempt to model the influnce of dykes, the above diagram is reproduced from "Weijwemars - Structural Geology and Map Interpretation". The figure shows the geometry of a magmatic complex, including: stock, dyke, sill and laccolith in the subsurface, and lava flows, neck and caldera at the surface.

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Tutorial K1: Create the PlatDykes 3D GeoModeller Project

Parent topic: Tutorial case study K (Dykes)

In this tutorial we load a 3D GeoModeller project and examine the components of the 3D GeoModeller workshops.

In the tutorial:

- K1 Steps
- K1 Discussion
- K1 More information

K1 Steps

Parent topic: Tutorial K1: Create the PlatDykes 3D GeoModeller Project

1 Launch 3D GeoModeller from the desktop icon

The 3D GeoModeller welcome screen appears with a main menu and toolbars arranged across the top, left and right sides. Only 3D GeoModeller V2.0 and greater supports dykes.

Figure 1. 3D GeoModeller V2.0 welcome screen.

2 Create the start-point 3D GeoModeller project.

From the main menu choose **Project > New** or
from the **Project** toolbar choose **New** or
press CTRL+N

In the **Create a project** dialog box browse to choose the parent directory of the new project and set the project name to something like TutorialDyke1.

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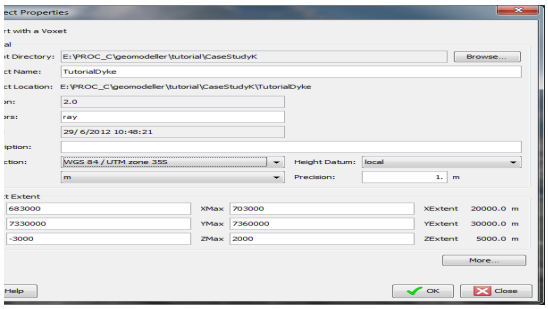
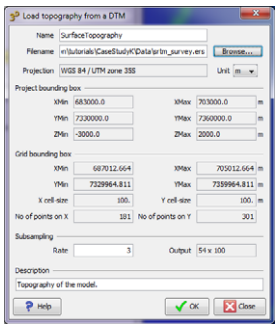
For this project the project dimensions and coordinate system (Datum and Projection) are:

- **Projection**—WGS84/UTM zone 35S
- **Height Datum**—Local
- Extents

	Minimum	Maximum	Range
East	683,000	703,000	20,000 m
North	7,330,000	7,360,000	30,000 m
Z-axis	–3,000	2,000	5,000 m



3 Set the DTM for this project. The grid to be used is in the **Data** directory for this tutorial. The name of the SRTM file is **srtm_survey.ers**



4 Save your own copy of this project, so that you can always start again from this point in the workflow.

From the main menu choose **Project > Save as** or
from the **Project** toolbar choose **Save As** or
press CTRL+SHIFT+S.

Save your project work as **dyke1** in a folder outside the original **StartTutorial** folder. For example, one folder up: **GeoModeller\tutorial\CaseStudyK**

Use *Windows Explorer* to review the files that make up the 3D GeoModeller project. You can see that you have created a folder called **dyke1**, within which are all of the files that constitute this 3D geology project. These also use the base filename **TutorialK**.

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K1 Discussion

Parent topic: Tutorial K1: Create the PlatDykes 3D GeoModeller Project

Examine the main elements of the 3D GeoModeller workspace.

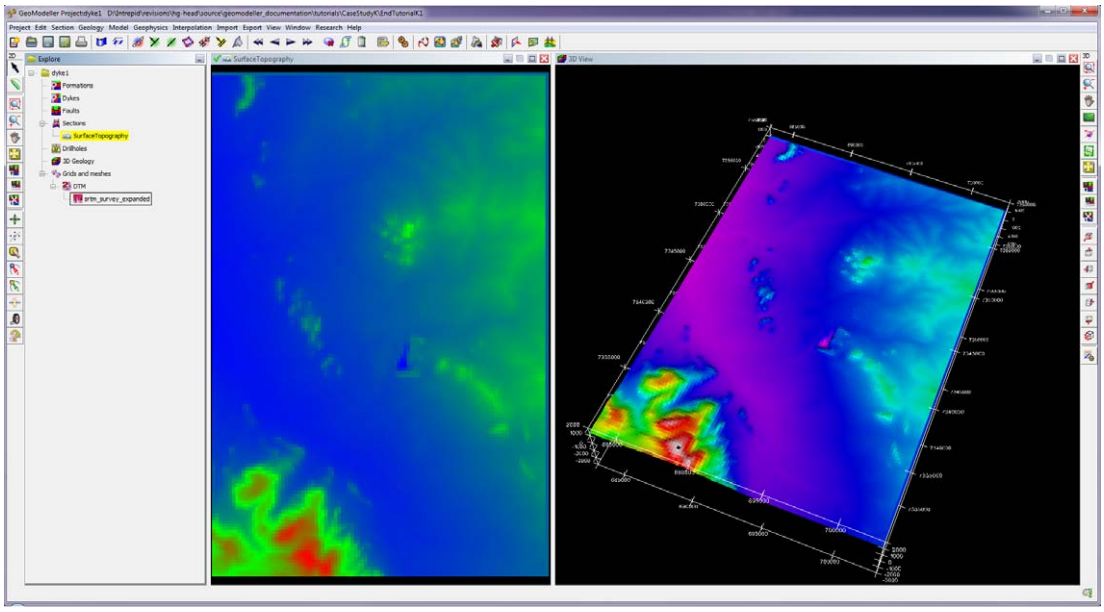

Figure 2. 3D GeoModeller End of section K1 tutorial, showing the Digital Terrain Model.

Note in particular:

- **Project Explorer**—this has a tree structure containing the many objects that make up our 3D geology project: Formations, Faults, Models, Sections, Drillholes, etc.
- **2D Viewer**—contains 2D sections. This Tutorial K1 project contains several sections—a special one—the 'geological map view' (labelled as TopoMap in this project), and four vertical cross-sections. We use the sections for data input, and for examining 2D plots of our 3D model.
- **3D Viewer**—contains the 3D view of our project. At this stage it shows only the bounding extents of the project. The yellow lines are the outlines of the TopoMap section (the topography of the project area) in the 3D Viewer, and the four vertical sections.
- **MeshGrids** —contains the DTM grid as a separate item to be queried, manipulated, visualized. Both the 2D and 3D view have the DTM displayed using a default colour look up table. the shortcut (right click) menu shows all the query options.

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K1 More information

Parent topic: Tutorial K1: Create the PlatDykes 3D GeoModeller Project

Some comments about the 3D GeoModeller project space:

- X (East), Y (North) and Z (Elevation, positive upwards) are a standard coordinate framework according to a right-hand rule
- X, Y and Z are all in the same units—metres (Cannot be degrees of latitude or longitude)
- X and Y would typically be real world projected coordinates, but could be a local mine grid, etc.
- Z is Elevation, and is positive upwards. It also would typically use a real world vertical datum such as mean sea level
- You can (and should) define the Projection (actually a Coordinate System, consisting of a Datum and Projection)
- All data must be within the project limits; data outside those limits cannot be imported or created
- Likewise all modelled results—geology lines, polygons and surfaces—are within those limits

So, when you create your own project, make the project dimensions large enough to include all geology data used in the project.

Remember to allow for the full topographic height of the project area:

- We recommend that you leave, say, 5–10% extra space at the top of the project, above the highest point of the topography
- Allow sufficient project space at the bottom for the entire range of modelled geology that you are interested in. Don't, however, make it too large or you will take extra time to compute model shapes that are of no interest

The topography map view (TopoMap) in a 3D GeoModeller project is a special (pseudo-non-planar) section, and it is an essential part of the project. You cannot do any practical work in a 3D GeoModeller project until the map view section has been created. Since topography defines the natural upper limit of a typical 3D geology model, we use a digital terrain model (DTM) file to correctly define the shape of this special TopoMap section. Using the correct topographic shape has geology mapping advantages, and we recommend it.

Once the DTM (topography) has been loaded, and the map view section created (called TopoMap in this project), the 3D GeoModeller project dimensions cannot be changed.

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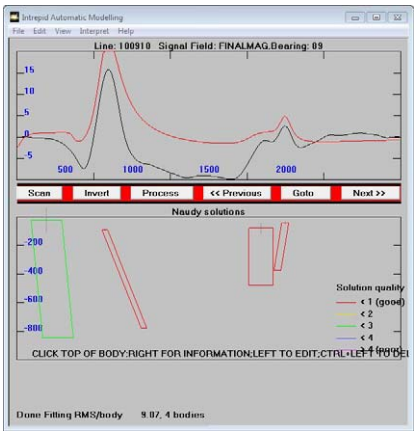
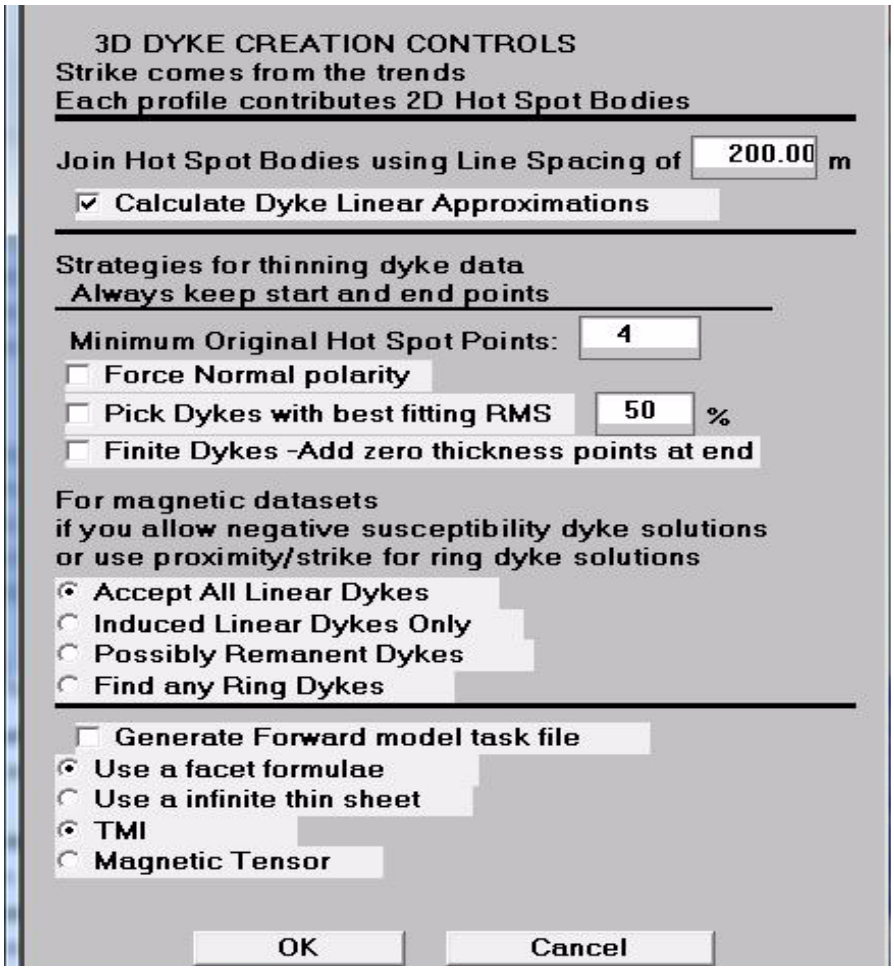
Tutorial K2: Examine then Import Project Dykes

Parent topic: Tutorial case study K (Dykes)

The Tutorial K1 3D GeoModeller Project that we have just loaded already has an automatic interpretation of 'hot spot'dyke locations available as a **.csv** file. This file is the output of the INTREPID NaudyD tool. A seperate cookbook tutorial exists to explain how to get a good result from any airborne magnetic survey.



There are options to choose the character of the dykes you wish to see selected by the clustering and sorting algorithm. These are shown below. The options have been tuned to assist you in having the best chance of getting some observations of the dykes in your project that will remain coherent and controlable as you attempt a 3D interpretation.


3D DYKE CREATION CONTROLS
Strike comes from the trends
Each profile contributes 2D Hot Spot Bodies
Join Hot Spot Bodies using Line Spacing of 200.00 m
Calculate Dyke Linear Approximations
Strategies for thinning dyke data
Always keep start and end points
Minimum Original Hot Spot Points: 4
Force Normal polarity
Pick Dykes with best fitting RMS 50 %
Finite Dykes -Add zero thickness points at end
For magnetic datasets
if you allow negative susceptibility dyke solutions
or use proximity/strike for ring dyke solutions
Accept All Linear Dykes
Induced Linear Dykes Only
Possibly Remanent Dykes
Find any Ring Dykes
Generate Forward model task file
Use a facet formulae
Use a infinite thin sheet
TMI
Magnetic Tensor
OK
Cancel

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In this section:

- K2 Overview
- K2 Stage 1—Examine the HOT-SPOT dyke data
- K2 Stage 2—Explore model plotting options
- K2 Stage 3—Explore the 3D Viewer

K2 Overview

Parent topic: **Tutorial K2: Examine then Import Project Dykes**

In this tutorial we:

1. Examine the 'hot spot' dyke mapping data.
2. Import the Dyke Mapping data via as data located on the topography.
3. Review the Project's stratigraphic pile
4. Compute the geology model, and plot modelled geology in map and section views (**2D Viewer**)
5. Build 3D shapes of the geology model and examine (**3D Viewer**)

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K2 Stage 1—Examine the HOT-SPOT dyke data

Parent topic: Tutorial K2: Examine then Import Project Dykes

1 If it is not already open, open your project, or the supplied start-point 3D GeoModeller project for Tutorial K1.

From the main menu choose **Project > Open** or
from the toolbar choose **Open** or
press CTRL+O

(For the start-point project supplied) In the **Open a project** dialog box navigate to the 3D GeoModeller Project **`.xml`** file **`GeoModeller\tutorial\CaseStudyK\StartTutorialK2\dyke2.xml`** . The dyke data is in the Data directory and is called "project_dykes.csv".

```
// 3D Dykes Data  from naudyd. kluge from digitized stuff as well
// Map Projectio  n SUTM53/WGS84
Dyke    X          Y         Depth  Thickness Height Strike Plunge Susceptibility Similarity RMS Mag_Azimuth
Mag_inclination
Dyke5,690337.77, 7334537.86,   188.8,   173.7,  5868,  60.0, 60, 0.00190, 2.42, -1.0,   6.2, -62.8
Dyke5,689418.10, 7333562.44,   310.9,   393.1,  1965, 50.0, 48.0, 0.00020, 2.48, -1.0,   6.2, -62.8
Dyke5,700122.57, 7348562.02,   308.8,   393.1,  1965,  35.0, 73.2, 0.00020, 2.24, -1.0,   6.2, -62.8
Dyke5,699046.24, 7346283.78,    44.8,   131.6,   658, 40.0, 65, 0.00009, 1.62, -1.0,   6.2, -62.8
Dyke5,697880.21, 7344104.20,   390.7,   471.7,  2358, 45.0, 56, 0.00036, 2.49, -1.0,   6.2, -62.8
Dyke5,697368.95, 7343261.07,     7.2,    91.4,   457, 50.0, 50, 0.00003, 2.84, -1.0,   6.2, -62.8
Dyke5,696176.01, 7341673.48,   305.9,   393.1,  1965, 52.0, 67.7, 0.00421, 1.46, -1.0,   6.2, -62.8
```

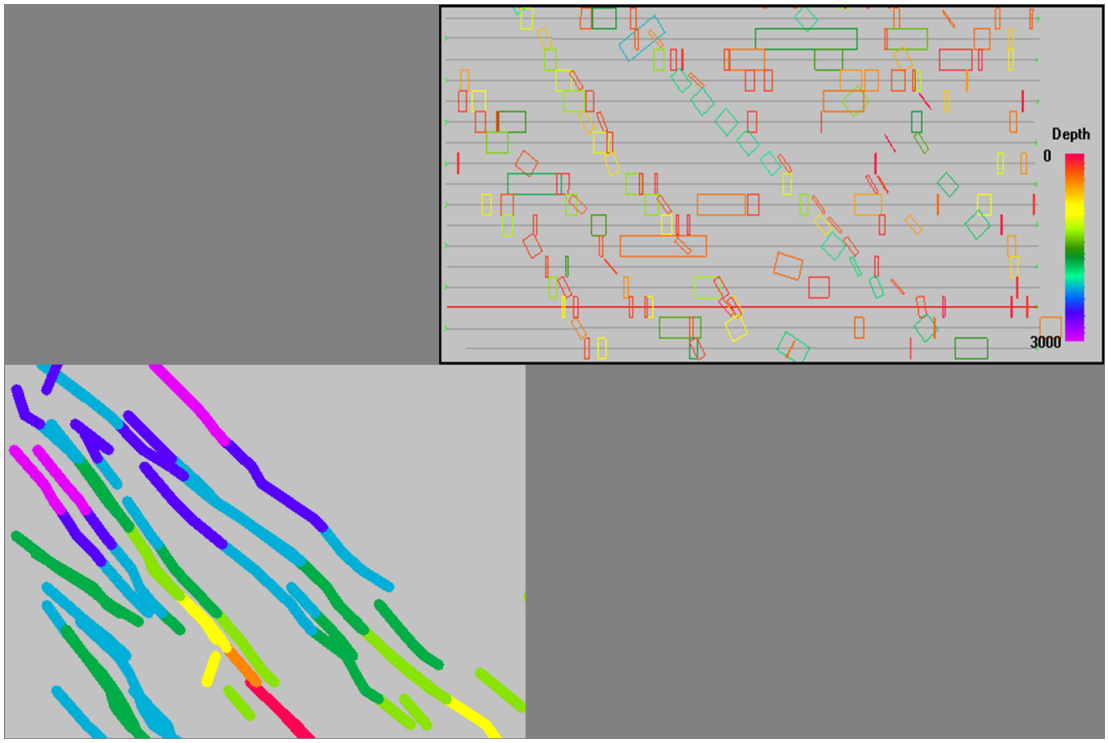

Figure 2a. Plan view of Naudy tool, showing aeromagnetic profile lines, 'hot spot' solutions, then sorted'

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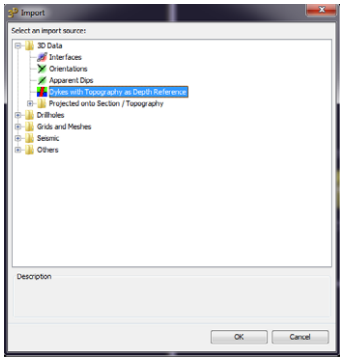
Notes on HOT-SPOT format.

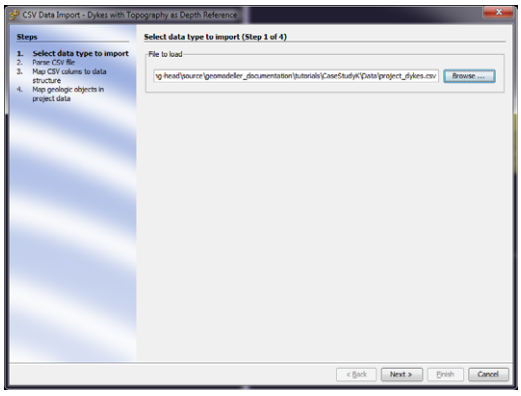
This format must contain standard fields that capture the essential features of an observation of a dyke. Required fields are :

- Location X & Y
- Depth to top of dyke, below surface
- Length - can be set to a constant, say 200m
- Strike
- Plunge
- Thickness
- Susceptibility - can be set to 0.0
- Magnetic Azmiuth - can be set to 0.0
- Magnetic Declination - can be set to 0.0

2 Import the dykes. With V2.0, many new options are supported. This includes direct support for most geohysical database formats, as well as the usual ASCII styles. In this case, we show the ASCII “csv” importer at work. Choose from Main menu Import>Import>.3D Data>Dykes



Now Browse to this required file with the CSV import Wizard, panel1


Steps
1. Select data type to import
2. Parse CSV file
3. Map CSV columns to data structure
4. Map geologic objects in project data
Select data type to import (Step 1 of 4)
File to load
Browse ...
< Back
Next >
Finish
Cancel

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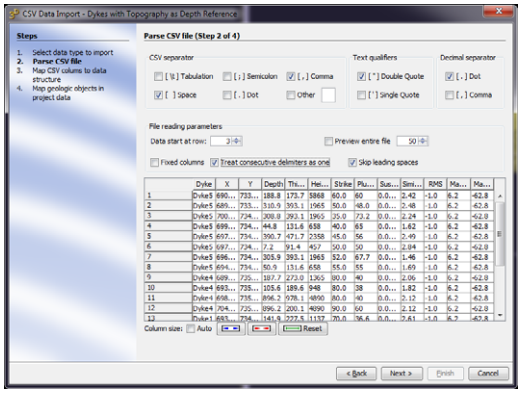
With the Next Wizard panel, the most important lessons to be learnt are:

- Set data to start at row 3
- Treat consecutive delimiters as one
- Choose both Comma ans Space delimiters.



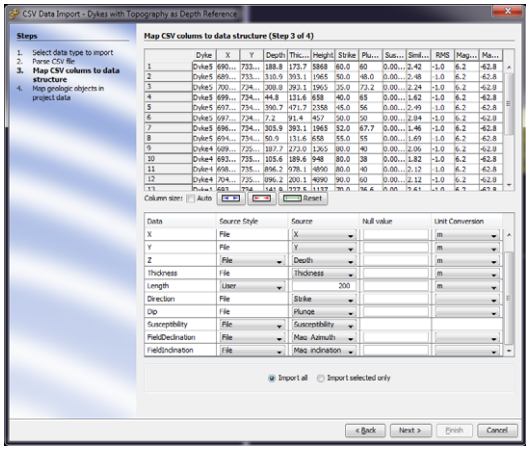
The next Wizard pane requires you to match the fields from the CSV file to the required fields with the Dyke Importer protocols. Most of the default selected fields are exactly what is required. The exceptions are :

Z -> Depth (This is the depth below surface to top of Dyke)

Length should be changed away from “FILE” to “USER” and then set to 200

FieldDeclination set to Mag Azimuth

FieldDeclination set to Mag inclination



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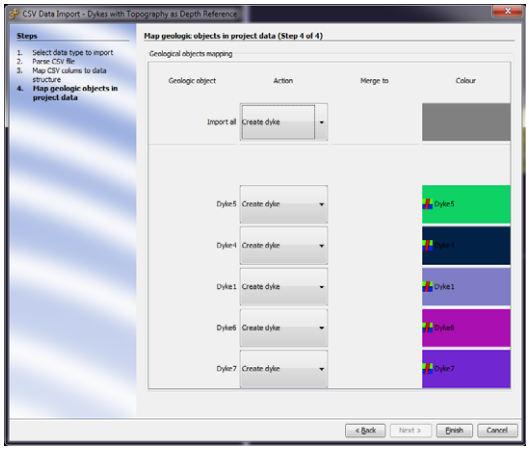
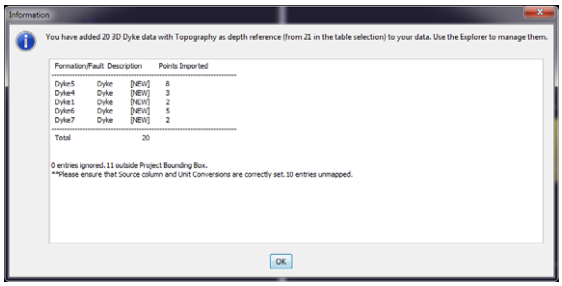
The final Wizard pane assigns default colours to the incoming dyke intrusives, once you choose to “Create dyke” in the Import all drop down list.



When the data is processed, a small report is popped up for you to examine, that records the status of the import job.



The import process has created 5 new Dykes in the strategraphic pile, that are initially defined using 20 field observations of an interface with an associated foliation and thickness. This particular combination only applies to the first data that is assigned to a Dyke formation. In effect, we use the exact same interface and foliation primative data points as elsewhere, but impose the special condition that the foliation must be associated with a pre-decalred Dyke formation. Then the final piece of the puzzle is to allow a thickness of the Dyke to be specified at the same observation point. This same approach can be used to input an observation into 3D GeoModeller of a manually digitized dyke. Note that the limitaion introduced here is that the observation is constained to the Topography surface and the interface must also be defined by 2 near by points (not the normal one). Once an initial observation point is established, the usual rules for extra interface and foliation points anywhere in 3D space can still be applied, to further guide where the dyke model should appear in your model.

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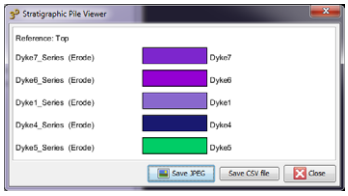
3 From the main menu choose **Geology > Stratigraphic Pile: Visualise** to open the **Stratigraphic Pile Viewer**. The Dykes have been added to the Strategraphic pile, each with their own series and each with an Erosional or Intrusive character. It should be noted that the default time order of the dykes in the pile follows the same order as in the imput file, ie the yougest are at the top of the file. It is a simple manner to change the order in the strategraphic pile editor.



4 Compute the 3D geology model for the Project that we have loaded (to be constrained by the geological data existing within the current Project).

From the **Model** toolbar, choose **Compute** or press CTRL+M

In the **Compute the Model** dialog box:

- **Series to interpolate**—Select All
- **Faults to interpolate**—Select All
- **Sections to take into account**—Select All
- **Faults only**—Clear (therefore DO compute faults)
- Choose **OK**

3D GeoModeller computes the model. (Nothing to see yet.) The model is a mathematical model—a set of interpolator equations that are computed from the geology contacts and orientation data. There is an interpolator equation for each series, including each dyke, in the stratigraphic pile, and also an equation for each fault.

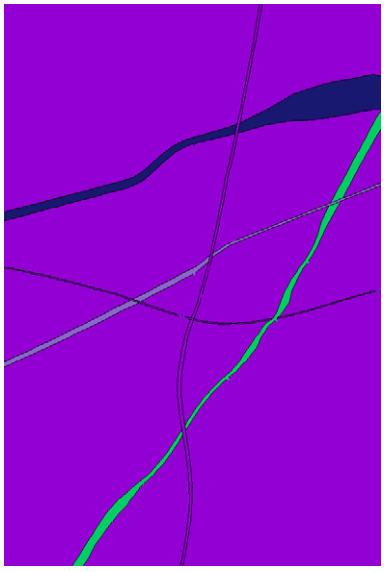


Figure 3. Dyke map of the PlatDykes Project - note the cross-cutting and the variable thickness.

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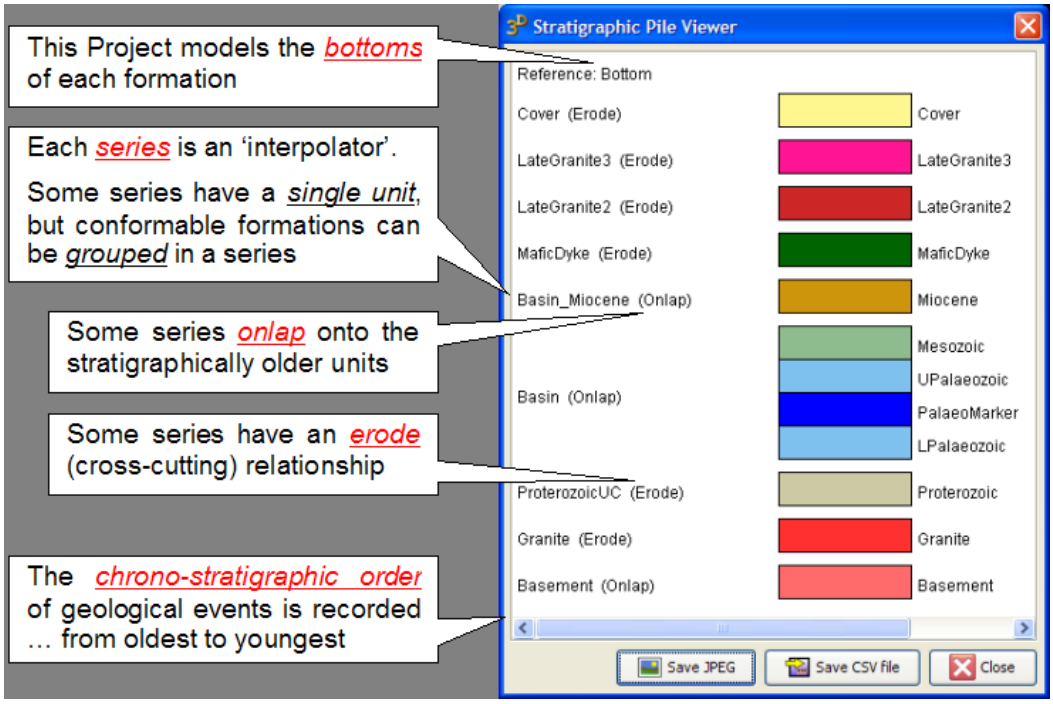

Figure 4. Stratigraphic Pile for the PlatDykes (Tutorial K2) Project.

View the modelled geology

To see the modelled geology, we need to interrogate the model equations. We can:

- Plot the modelled geology on the TopoMap 2D section (the Project's geological map)
- Plot the modelled geology on any other 2D cross-section
- Build the 3D shapes of the modelled geology, and view in the **3D Viewer**

5 Select **TopoMap** in the **2D Viewer** (click it)

6 From the **Model** toolbar, choose **Plot the model settings** or press CTRL+D

In the **Plot the model settings** dialog box:

- Check **Show lines**
- Choose **OK**

The lines of the modelled geology are plotted on the TopoMap 2D Section (map).

7 Save your project

From the main menu choose **Project > Save** or
from the toolbar choose **Save** or
press CTRL+S.

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K2 Stage 2—Explore model plotting options

Parent topic: Tutorial K2: Examine then Import Project Dykes

1 Experiment with other options in the **Plot the model settings** dialog box:

- Check **Show fill** to plot 'solid' geology
- Choose **Apply to All** (sections) to plot all (open) 2D sections
- For **Show lines** or **Show fill**, select or de-select various combinations of formations
- Choose **Show trend lines** in combination with **Show lines** or **Show fill**
- Modify the Plotting resolution from the default u=50, v=50 to, say, 100 x 100

2 Experiment with the three plot buttons in the **Model** toolbar:

- **Plot the model settings** or press CTRL+D
- **Plot the model on the current section**
- **Plot the model on all sections**

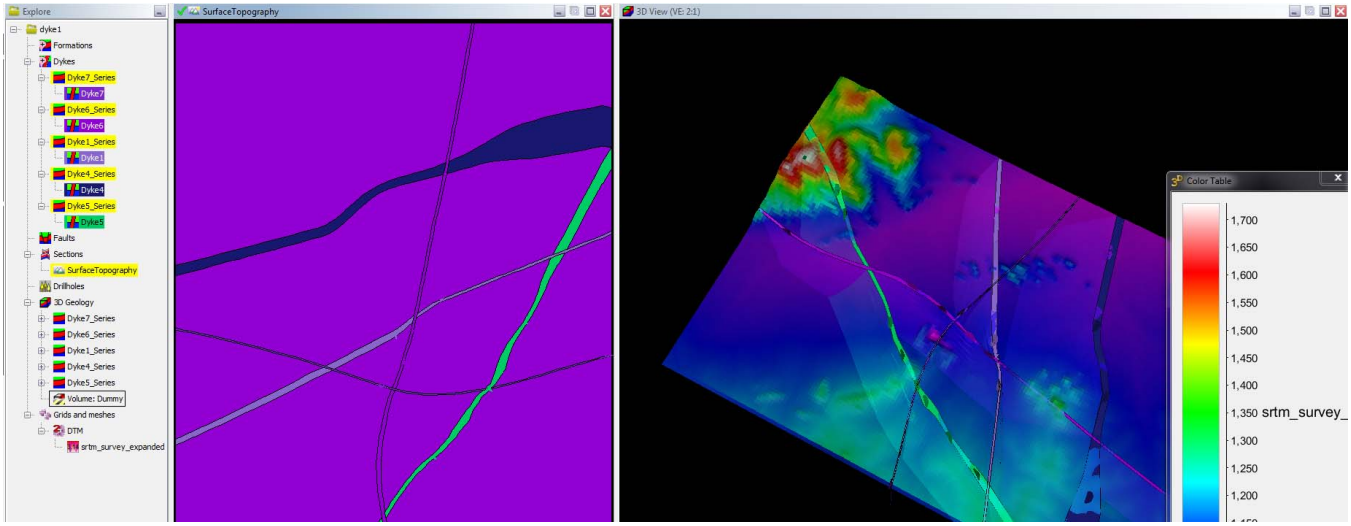

Figure 5. Various plots options displaying the 3D geology model on Sections TopoMap.

3 Save your project

From the main menu choose **Project > Save** or from the toolbar choose **Save** or press CTRL+S.

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K2 Stage 3—Explore the 3D Viewer

Parent topic: Tutorial K2: Examine then Import Project Dykes

1 View the model in 3D:

- From the **Model** toolbar choose **Build 3D Formations and Faults**
- In the **Build 3D Formation and Fault Shapes** dialog box:
  - Check **Build**—**Formations**
  - Leave UnChecked **Build**—**Faults (you do not have any as yet)**
  - Select **Type**—**Volume**
  - Check **Draw Shapes after building**
  - Adjust the **Resolution**—**Render quality** to High
  - Choose **OK**

3D GeoModeller computes the 3D shapes of the dyke model as 'volumes' defined by triangle mesh surfaces, which it displays in the 3D Viewer. As there are many implicit fields being used when there are many dykes and there is a requirment to honour the variable thickness of the thin bodies, this rendering takes longer than for most other cases.

2 Use the **Project Explorer** (typically on the left-side of your work space) to manage the display of modelled objects in the 3D Viewer. Note that the **Dykes** appear in the tree below the **Formations** and above the **Faults**. The **3D Geology** tag is only populated once the 3D shapes for your model have been computed.

- In the **Project Explorer** right-click **3D Geology >** and select **Hide**—to hide the entire modelled geology
- In the **Project Explorer** right-click **3D Geology >** and select **Show**—to show again the entire modelled geology

  The **Hide** or **Show** options toggle from one to the other.
- In the **Project Explorer** right-click **3D Geology >** and select **Wireframe**—to change the displayed 3D volumes to wireframes
- In the **Project Explorer** right-click **3D Geology >** and select **Shading**—to toggle the 3D display of geology back to shaded

  The **Wireframe** or **Shading** options toggle from one to the other.

3 Display the plotted geology (2D) sections in the **3D Viewer**

- With any **2D Viewer** window selected (for example, sAA) from the shortcut (right-click the background of the 2D viewer), and choose from the Menu:
  - **Show modelled geology polygons in 3D Viewer**
  - or, **Show modelled geology lines in 3D Viewer**
  - **Hide modelled geology polygons in 3D Viewer**

  These menu items toggle between **Hide** and **Show**.

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4 Display the 3D mapping points by using right mouse button and choosing both Interfaces and Foliations for any/all of your dykes

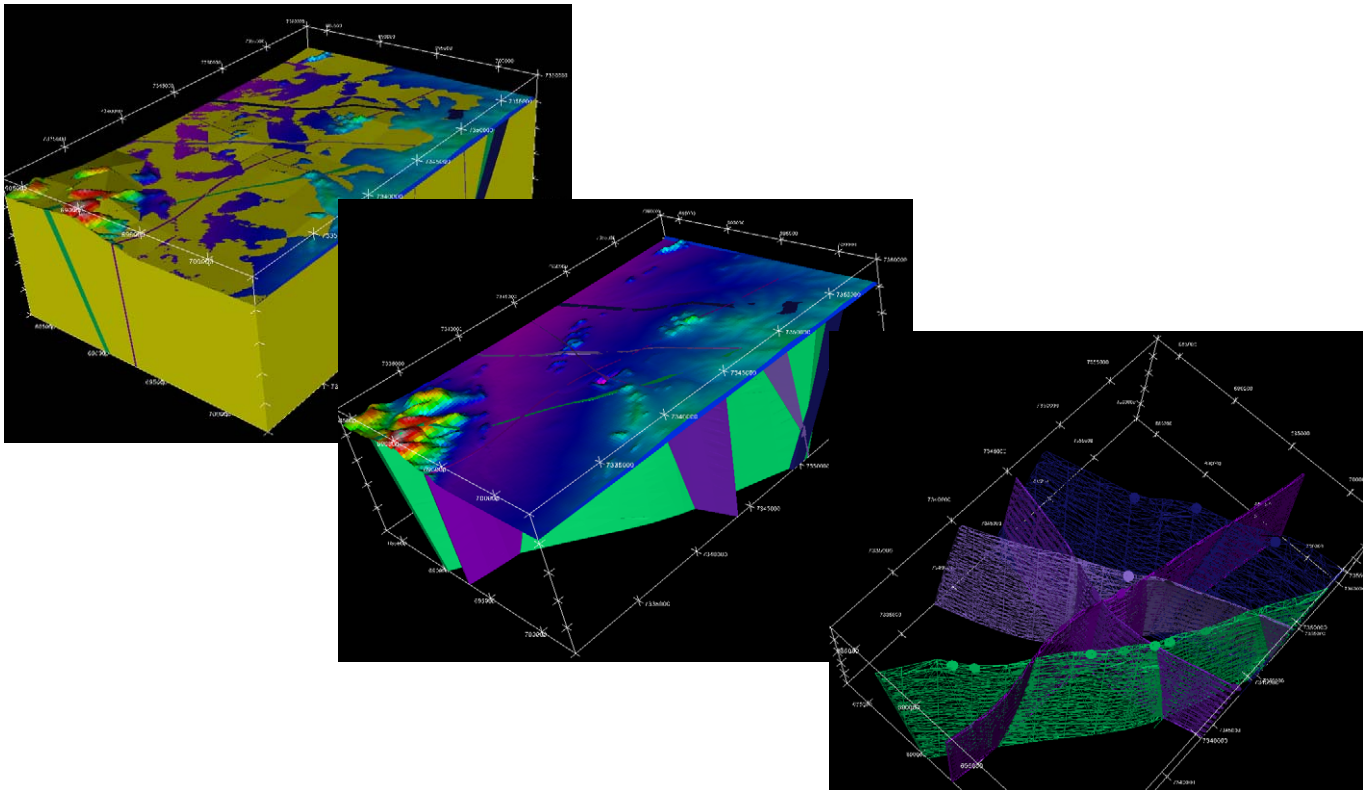

Figure 6. Various 3D plots of the 3D geology model, including one showing the HOT-SPOTs.

5 Save your project

From the main menu choose **Project > Save** or
from the toolbar choose **Save** or
press CTRL+S.

Discussion—What data have been used to make this model?

We have now examined this project in traditional 2D views, and also in a 3D Viewer, but what data have been used to make this model?

We have used the following geological facts and interpretive data:

- The stratigraphic order of events and the rock relationships—both recorded in the stratigraphic pile
- Mapped dyke contacts on the TopoMap surface section
- Some co-incident field-measured orientation data, also on the TopoMap section

To examine these actual data, use the **Project Explorer** to investigate the geology interface and orientation data catalogued within, and find the corresponding data for each lithology stored in structures linked to either: 2D Sections, or Drillholes.

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Tutorial K3: Update Stratigraphy Order of Dykes

Parent topic: Tutorial case study K (Dykes)

We want to change the Dyke5 intrusive to our geology model. We update the stratigraphic pile. In this section:

- K3 Overview
- K3 Steps

K3 Overview

Parent topic: Tutorial K3: Update Stratigraphy Order of Dykes

In this tutorial we:

1 Place Dyke5 in the correct chrono-stratigraphic order in stratigraphic pile for the Project

2 Declare the rock relationship. In this case it cuts across the older stratigraphy

K3 Steps

Parent topic: Tutorial K3: Update Stratigraphy Order of Dykes

1 If it is not already open, open your project **dyke3** or the supplied start-point 3D GeoModeller project for Tutorial K3.

From the main menu choose **Project > Open** or
from the toolbar choose **Open** or
press CTRL+O

(For the start-point project supplied) In the **Open a project** dialog box navigate to the 3D GeoModeller Project **.xml** file

GeoModeller\tutorial\CaseStudyK\StartTutorialK3\StartTutorialK3.xml

2 Save a copy of this project in your own data area.

From the main menu choose **Project > Save** as or
from the toolbar choose **Save As** or
press CTRL+SHIFT+S.

Save your project work as **dyke4** in a folder outside the original **StartTutorial** folder.

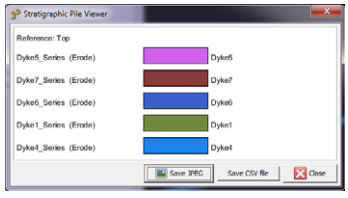
3 From the main menu choose **Geology > Stratigraphic Pile: Create or Edit**

4 In the **Create or Edit geology series and the stratigraphic pile** dialog box:

- For future reference, note that **Top** is the chosen option; for this project we model 'top' of formations (i.e., all data entered is assumed to relate to the chronologically, top-boundary of the given geology unit, where it contacts with the unit below).

5 In the **Create or Edit geology series and the stratigraphic pile** dialog box:

- Check that the series are in the correct stratigraphic order, with this late-stage Dyke5 placed towards the top of the list, above the other Dykes (select the new series, and use the **Move up** and **Move down** buttons as required).



- Then **Close**

6 From the main menu choose **Geology > Stratigraphic Pile: Visualise**

7 In the **Stratigraphic Pile Viewer** dialog box, review and then **Close**

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8 Save your project

From the main menu choose **Project > Save** or from the toolbar choose **Save** or press CTRL+S.

Tutorial K4: Add Geology 2—Digitise and Recompute the Model

Parent topic: Tutorial case study K (Dykes)

Having updated the stratigraphic pile in Tutorial K3, we can now digitise the an Archean Granite dyke, and build a revised 3D geology model.

In this section:

- K4 Overview
- K4 Stage 1—Digitise the Dyke5 geology contact
- K4 Stage 2—Recompute and visualise in 2D and 3D

K4 Overview

Parent topic: Tutorial K4: Add Geology 2—Digitise and Recompute the Model

In this tutorial we:

1 Digitise the ArcheanGranite1 dyke contact

2 Recompute the 3D geology model

3 Again examine the 3D geology model in 2D and 3D views

K4 Stage 1—Digitise the Dyke5 geology contact

Parent topic: Tutorial K4: Add Geology 2—Digitise and Recompute the Model

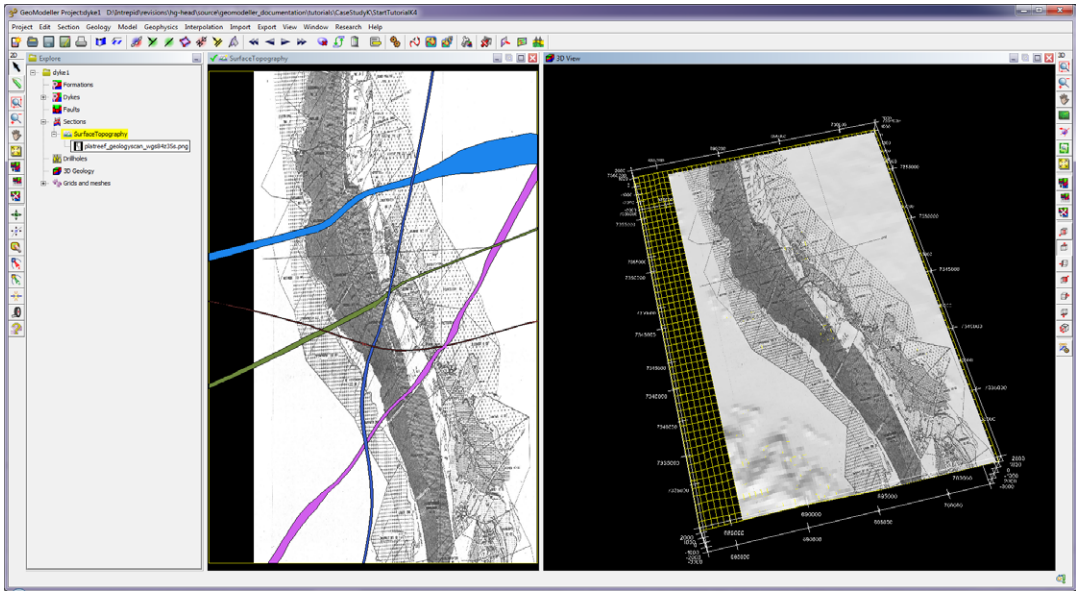
K4 Stage 1—Steps

1 If it is not already open, open your project **dyke** or the supplied start-point 3D GeoModeller project for Tutorial K4.

From the main menu choose **Project > Open** or from the toolbar choose **Open** or press CTRL+O

(For the start-point project supplied) In the **Open a project** dialog box navigate to the 3D GeoModeller Project `.xml` file

`GeoModeller\tutorial\CaseStudyK\StartTutorialK4\StartTutorialK4.xml`



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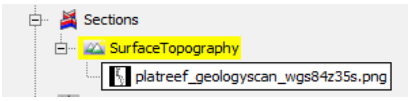
2 Save a copy of this project in your own data area.

From the main menu choose **Project > Save** as or from the toolbar choose **Save As** or press CTRL+SHIFT+S.

Save your project work as **dyke5** in a folder outside the original **`StartTutorial`** folder.

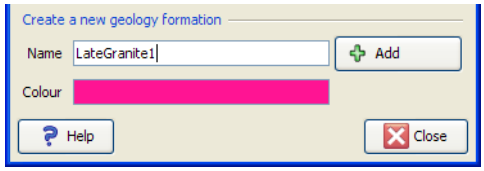
3 Show the geo-registered image of the geology. From the **Explore Tree view**, Surface Topography section shortcut menu, choose **`Platreef_geologyscal_wgs84z35s.png`**



Note the hand drawn geology map is not strictly registered with the dykes we have so far. This was never the intent with this exercise, but now is the point where we can add a non-magnetic granite body mapped in the top centre, trending mostly due south of the project area. We will model this granite as ArcheanGranite1.

4 Create the ArcheanGranite1 geology object. From the main menu choose **Geology > Dykes: Create or Edit**

5 From the **Create or Edit dyke** dialog box (Create a new dyke formation):



- **Name**—ArcheanGranite1 (No spaces!)
- **Colour**—(pink (RGB = 255,20,147) used in this document)
- Choose **Add** and then **Close**

6 If prompted, in the **New formation creation** dialog box:

- Choose **Yes, start Stratigraphic Pile editor**

Alternatively:

- From the main menu choose **Geology > Stratigraphic Pile: Create or Edit**

7 In the **Create or Edit geology series and the stratigraphic pile** dialog box:

- For future reference, note that **Top** is the chosen option; for this project we model 'tops' of formations (i.e., all data entered is assumed to relate to the chronologically, top-boundary of the given geology unit, where it contacts with the unit above).
- Choose **New series**

8 In the **Create Geology Series** dialog box, confirm default entries, or change the following to:

- **Name of the series**—ArcheanGranite1_Series
- **Relationship**—Erode
- **Formations in Series**—ArcheanGranite1 (Ensure this formation is in the right-side list. Select formation(s) and use the **Add to Series** or **Remove from Series** buttons as required)
- The new series should be at the bottom of the pile.
- **Commit** then **Close**

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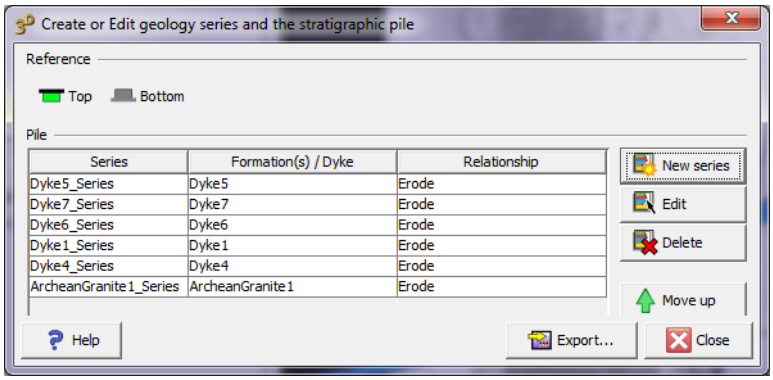
9 We are now ready to use that object when digitising a few contact data points along the granite boundary. We also need to create some associated orientation data to define the dyke as steeply dipping to the west.



10 From the **2D toolbar**, choose **Create** or press C

11 From the **Points List Editor** toolbar, choose **Delete all Points**

12 Starting at the top end, click two or three points along the granite dyke. For digitizing dykes, at least two points must e specified for each segment, so that the strike is locally established, and the thickness is a right angles to this "HOT-SPOT" interpretation, and then an associated dip can also be entered. This condition must be met, if you have chosen a Dyke formation. You cannot commit your input until this is done, for an associated Dyke foliation.

13 From the **Structural toolbar** choose **Create geology data** or press CTRL+G

14 In the **Create geology data** dialog box:

- **Geological Formations, Dykes and Faults**—select ArcheanGranite1
- This dialog box allows us to create some associated orientation data, too—these are orientation data created between each pair of digitised data points.
- Check on **Associated**
- Select **Dip constant**, and set Dip = 80 (degrees)
- **Polarity**—select **Normal**
- Thickness = 30 meters
- Choose **Create**, and then **Close**

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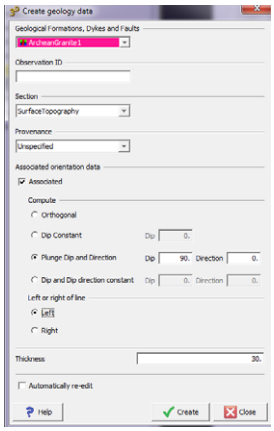
15 Save your project

From the main menu choose **Project > Save** or from the toolbar choose **Save** or press CTRL+S.



K4 Stage 1—Discussion

The two or three points that we clicked along the contact using the **Points List Editor** have been used to create geology contact data which define the local dyke of the ArcheanGranite1 at the TopoMap surface. In addition, associated orientation data have been created between each pair of points, each dipping at 90 degrees, in a direction orthogonal to each line segment. Note that the Points List is now empty; the points have been committed to ArcheanGranite1, and removed from the list. Repeat this again for the thinning section of the dyke as you go south. this time set the thickness to 15 meters.

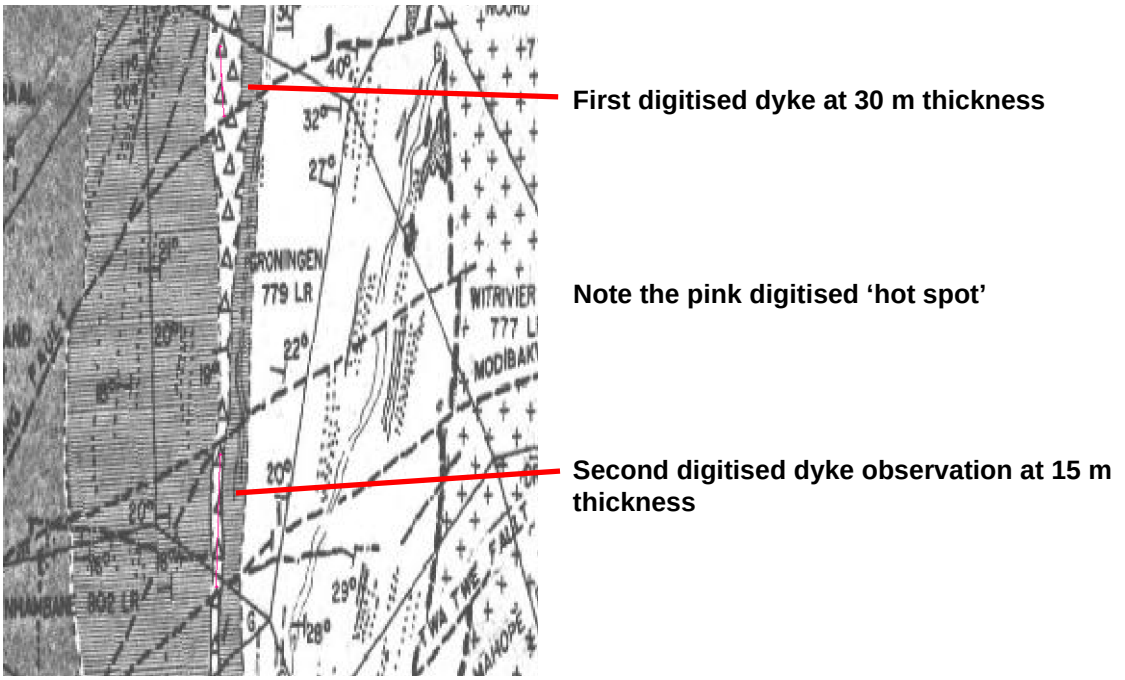


Figure 8. Digitised points in the Points List (of the Points List Editor) are made into 'observations' of the position of the ArcheanGranite1 by using the **Create geology data** dialog box.

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In order to build the 3D model of any surface—fault, dyke or geology formation—3D GeoModeller requires at least one point of contact (or fault position) data, and at least one point of orientation data, describing the attitude of that geology surface. Note that orientation data (of a surface) are entered by 'dip, and dip-direction' protocol in 3D GeoModeller.

Because we used the 'associated orientation data' case above, we have met the criteria, above, for building surfaces (need at least one point of contact [or fault position] data, and at least one point of orientation data).

K4 Stage 2—Recompute and visualise in 2D and 3D

Parent topic: Tutorial K4: Add Geology 2—Digitise and Recompute the Model

K4 Stage 2—Steps

1 From the **Model** toolbar, choose **Compute** or press CTRL+M

2 In the **Compute the Model** dialog box:

- Note that a new series—the ArcheanGranite1—is now available to be computed:
- Clear the 'Faults only' box
- Series to interpolate—**Select All**
- Faults to interpolate—Leave **unselected**
- Sections to take into account—**Select All**
- Choose **OK**

3 From the **Model** toolbar, choose from the available plotting options

- **Plot the model settings** or press CTRL+D
- **Plot the model on the current section**
- **Plot the model on all sections**

Repeat these steps, choosing different options to plot the geology model in different ways on one or more of the sections.

4 From the **Model** toolbar, choose **Build 3D Formations and Faults**

Visualise the revised geology model in the **3D Viewer**. Use the **Project Explorer** to **Show** or **Hide** different formations or units of the 3D geology model.

5 Save your project

From the main menu choose **Project > Save** or
from the toolbar choose **Save** or
press CTRL+S.

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K4 Stages 1 and 2—Discussion

Did your revision produce the expected granite dyke in the top, going south of the project area? To check this you need to plot 'solid geology' rather than 'lines', and compare your result with Figure 9, below.

If your solid geology map looks like Figure 9, your 3D geology model is correct; the ArcheanGranite1 body is a 3D body in the top/middle of the project.

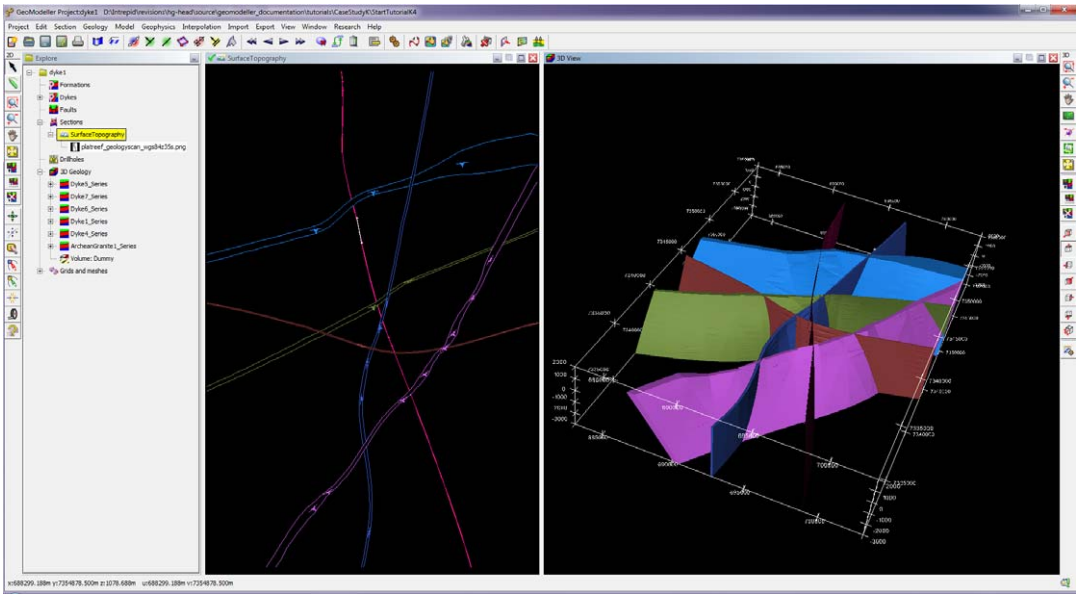

Figure 9. The geology map of the revised 3D geology model is correct in (a), with the ArcheanGranite1 appearing in the south-east corner. In (b) the 'associated' orientation data are dipping in the wrong direction, and the modelled ArcheanGranite1 plots on the incorrect side of the digitised contact.

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Tutorial K5: Import Drillhole Data and Recompute the Model

Parent topic: Tutorial case study K (Dykes)

The geology model at this point has been developed using geology observations derived mainly from surface geological mapping mostly derived from a geophysical interpretation. But things are about to change.

- One drillhole is now available, confirming the Dyke5 position at depth, and consequently the model requires major revision.

Change is easily implemented in 3D GeoModeller. Let's now make the changes.

K5 Overview

Parent topic: Tutorial K5: Import Drillhole Data and Recompute the Model

In this tutorial we:

1. Import data for a drillhole, and project the drillhole geology onto vertical cross-sections
2. Examine the Dyke5 interval in the 3D viewer
3. Examine the Dyke logging in the pop-up drill log viewer.
4. Note and respond to discrepancy between the new drillhole data and the existing 3D model

In this section:

- K5 Overview
- K5 Stage 1—Add drillhole data
- From the main menu choose Project > Save or from the toolbar choose Save or press CTRL+S.

K5 Stage 1—Add drillhole data

Parent topic: Tutorial K5: Import Drillhole Data and Recompute the Model

In this stage we add and examine the drillhole data

Load the project

1. If it is not already open, open your project **dyke4** or the supplied start-point 3D GeoModeller project for Tutorial K5.

   From the main menu choose **Project > Open** or
   from the toolbar choose **Open** or
   press CTRL+O

   (For the start-point project supplied) In the **Open a project** dialog box navigate to the 3D GeoModeller Project **`.xml`** file

   `GeoModeller\tutorial\CaseStudyK\StartTutorialK5\StartTutorialK5.xml`

2. Save a copy of this project in your own data area.

   From the main menu choose **Project > Save as** or
   from the toolbar choose **Save As** or
   press CTRL+SHIFT+S.

   Save your project work as **dyke6** in a folder outside the original **`StartTutorial`** folder.

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Load the drillhole data

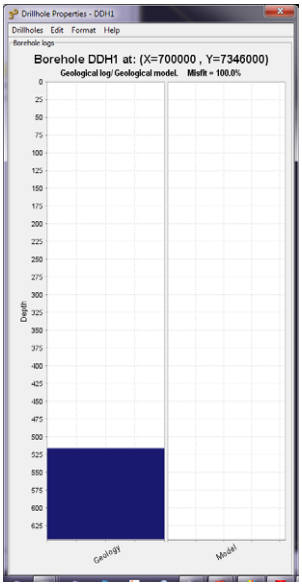
3 From the main menu choose **Import > Import Drillhole Data > Import Collars, Surveys, Geology (3 files)**

4 In the **Load Drillhole CSV dataset** dialog box:

- Browse to the 'Collar Table' file (**`Collars.csv`** in the **`CaseStudyK\Data\`** folder) and then use the drop-down lists of labelled 'columns' to assign the correct file columns to the fields required by 3D GeoModeller—the drillhole's Hole ID, its (X, Y, Z) collar coordinate and the Hole Depth.
- Similarly, browse to the 'Survey Table' file and assign the correct file columns to the required fields.
- Similarly, browse to the 'Geology Table' file and assign the correct file columns to the required fields.

5 Choose **OK**

The drillhole (DDH1) is now loaded, and a brief load report is presented.



6 From the explorer tree, click on the DrillHole>DDH1

The drillhole can also be displayed in the 3D Viewer (see Figure 10).

Show or Hide drillholes in the 3D Viewer

7 In the **Project Explorer**, choose **Drillholes > Show**—shows all drillholes in the 3D Viewer

8 In the **Project Explorer**, choose **Drillholes > Hide**—hides them from the view

Or, for a chosen drillhole either **Show** or **Hide** it

9 Next, let's examine the drillhole data relative to the original 3D geology model.

Examine these by plotting and visualising the new drillhole in 2D (Section) and 3D (Viewer). Consider the interpretive changes that you need to make to best accommodate the new drillhole data (Figure 10).

Use the same plotting options that we have used previously.

- Project the drillholes onto **Sections**
- Plot the geology on **Sections**
- Show the drillholes in the **3D Viewer**
- Display the section plots in the 3D **Viewer**
- **Build 3D shapes** and manage the **3D Viewer** display using **Project Explorer**

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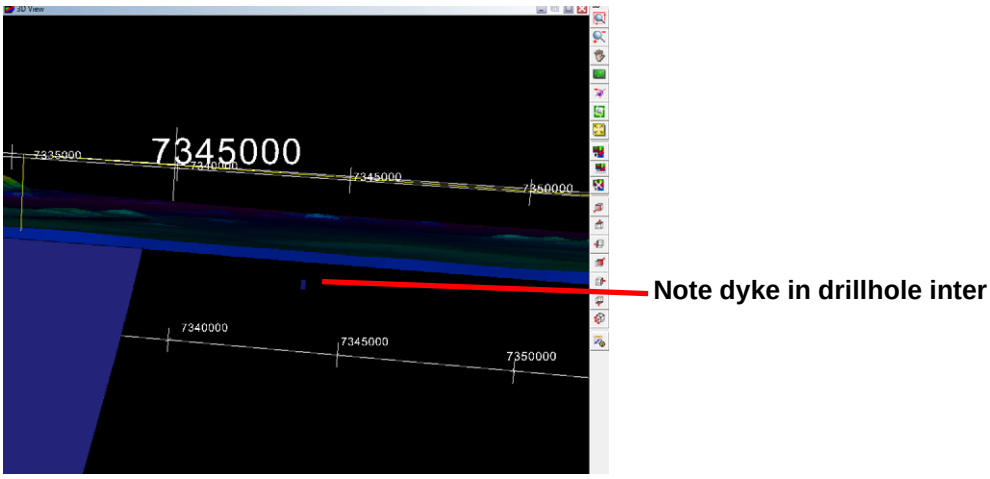

Figure 10. The 3D view shows the drillhole relative to the 3D modelled geology.

Now let's recompute the model so that the drill hole is taken into account.

10 From the **Model** toolbar, choose **Compute** or press CTRL+M

In the **Compute the Model** dialog box:

- **Series to interpolate**—Select All
- **DrillHoles to interpolate**—Select All
- **Sections to take into account**—Select All
- **Faults only**—Clear (therefore DO compute faults)

Choose **OK**

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11 Now re-plot and review the Recomputed, modelled geology. The geological interpretation-discrepancies will be confirmed (see Figure 10).

Perform steps as before (as in previous parts of this tutorial, for example, Tutorial K2 stages 1 to 3):

For 2D: From the **Model** toolbar, choose **Plot the model settings** or press CTRL+D

And for 3D: From the **Model** toolbar choose **Build 3D Formations and Faults**

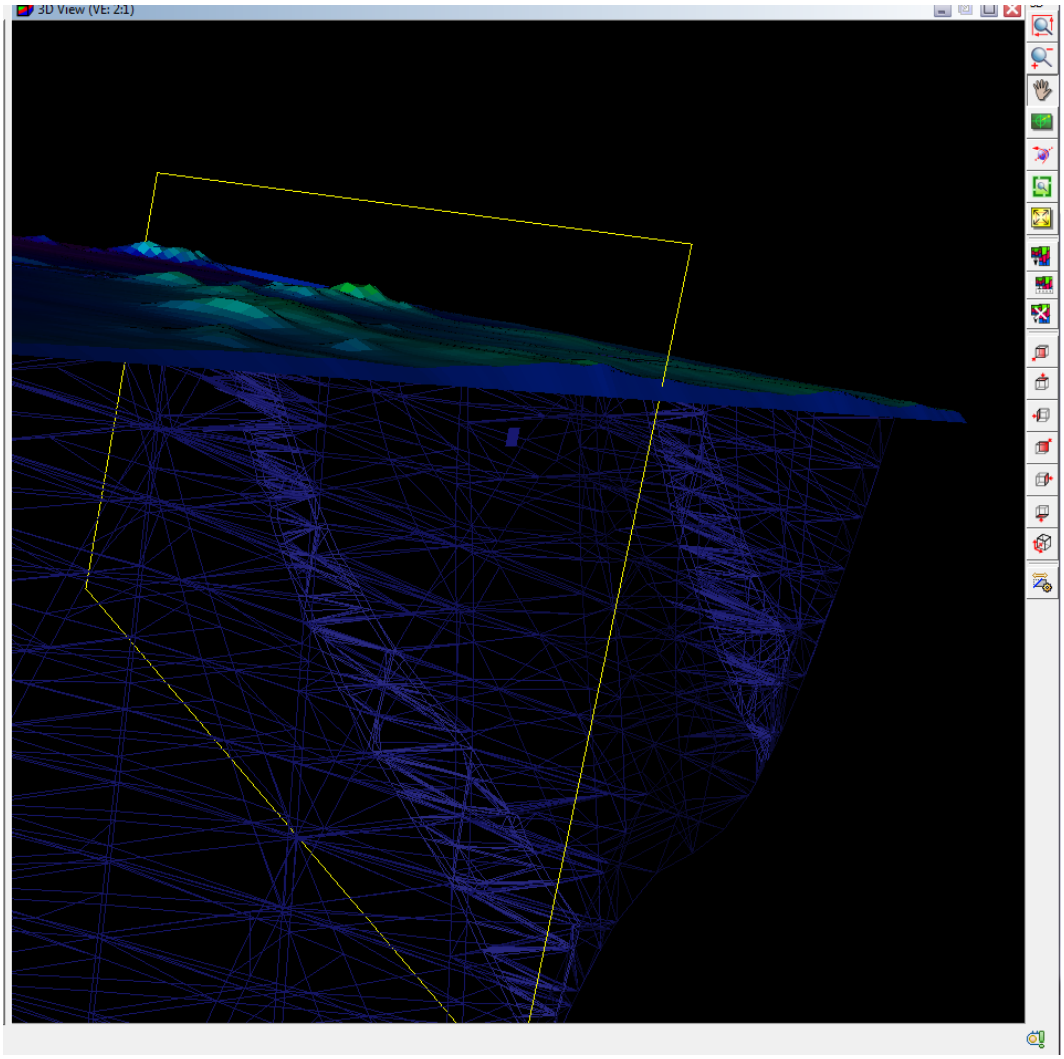

Figure 11. The TopoMap in 3D, together with Dyke5 showing geology for the recomputed model. The drillhole interval is now part of the geometry of the dyke.

12 Save your project

From the main menu choose **Project > Save** or from the toolbar choose **Save** or press CTRL+S.

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Tutorial K6: Review/Adjust the Magnetics Physical Property Data

In the exercise to date, each dyke has had physical properties automatically assigned to it during the Import CSV process. The properties are estimated in the companion "NAUDY" and profile data inversion steps. As each body is imported, its estimated susceptibility, has been stastically analysed, so that a Log Normal distribution can be automatically assigned to each dyke. We now add/adjust Magnetics physical property data for each dyke unit. The important properties are —the susceptibility, the magnetic declination and inclination.

If you are not using dyke data imported from an outside automatic modelling tool like NAUDY, you are responsible for setting up each dykes properties, prior to any attempt to run a forward model of the response of the dykes.

K6 Stage 1—Review susceptibility estimates

Parent topic: **Tutorial K5: Import Drillhole Data and Recompute the Model**

In this stage we examine the rock magnetic property data

Load the project

1 If it is not already open, open your project **dyke4** or the supplied start-point 3D GeoModeller project for Tutorial K6.

From the main menu choose **Project > Open** or
from the toolbar choose **Open** or
press CTRL+O

(For the start-point project supplied) In the **Open a project** dialog box navigate to the 3D GeoModeller Project **.xml** file

GeoModeller\tutorial\CaseStudyK\StartTutorialK6\StartTutorialK6.xml

Display physical properties in the geological formation dialog box - Information

1 From the main menu choose **Geophysics > Define physical properties**. 3D GeoModeller displays the **Physical properties of geological formation** dialog box. Some default values are shown as we have not set 'considered' values yet. You should choose the Magnetics TAB, as these are the only properties supported so far for the geophysics of dykes.

2 Activate the IGRF button and set the flying height to 80 meters. Just provide the date of the observed geophysics survey using the IGRF calculator, and these will adjust accordingly. Alternatively, you can manually enter the Total field (nT), Declination and Inclination from independent sources. **Each dyke has**

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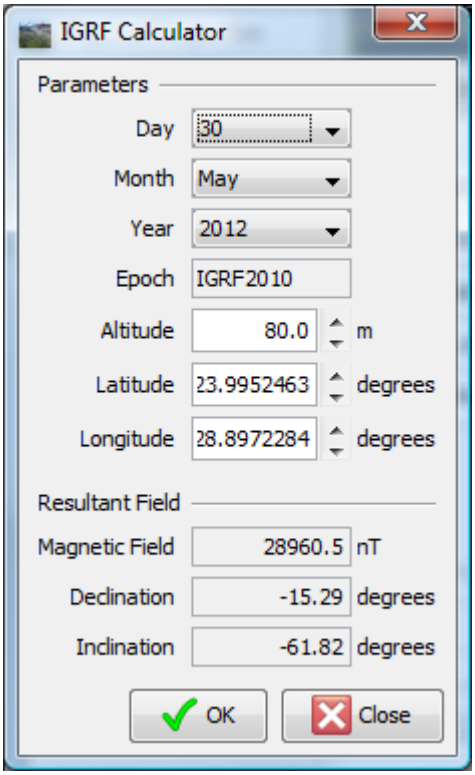
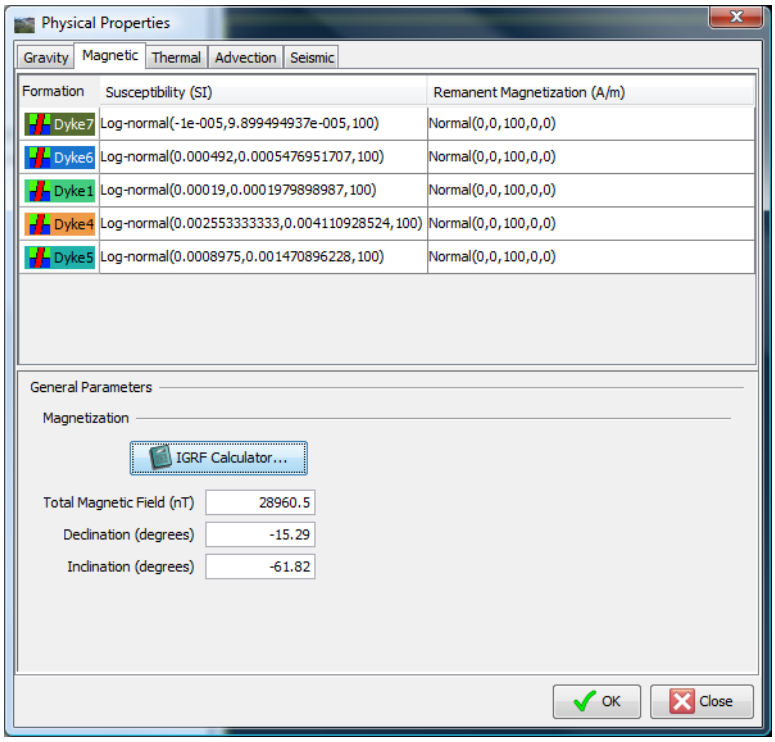
automatically been given its properties during the CSV import..



3 Now examine the Magetic susceptibilities that have been automatically setup for you during the import CSV process.



In each of the five tabs of the dialog box, the top section contains a table of physical properties for each formation in the geological pile. Double click within the appropriate cell to view or modify the parameters.

In the lower half of the magnetics tab of the dialog box you see the IGRF field settings.

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In the **Magnetic** tab, note that the **Total field (nT)**, Declination and Inclination are default values. This is due to a "local" co-ordinate system being set in this project (see Main Menu: Project > Properties). A real world co-ordinate system for the model would result in appropriate fields being automatically filled here.

As part of work in progress, each HOT-SPOT has an individual estimate of its susceptibility, height, length, thickness etc. The persistence model for Geomodeller is being extended to also capture not just a statistical law for the properties, but individual spatial distributions of dyke properties.

During the same session that an import was undertaken, the current V2012 also keeps the spatial distribution data and can use that to predict the forward response for each dyke, rather than use the mean for the whole dyke.

4 Close the Pop-up property panel.

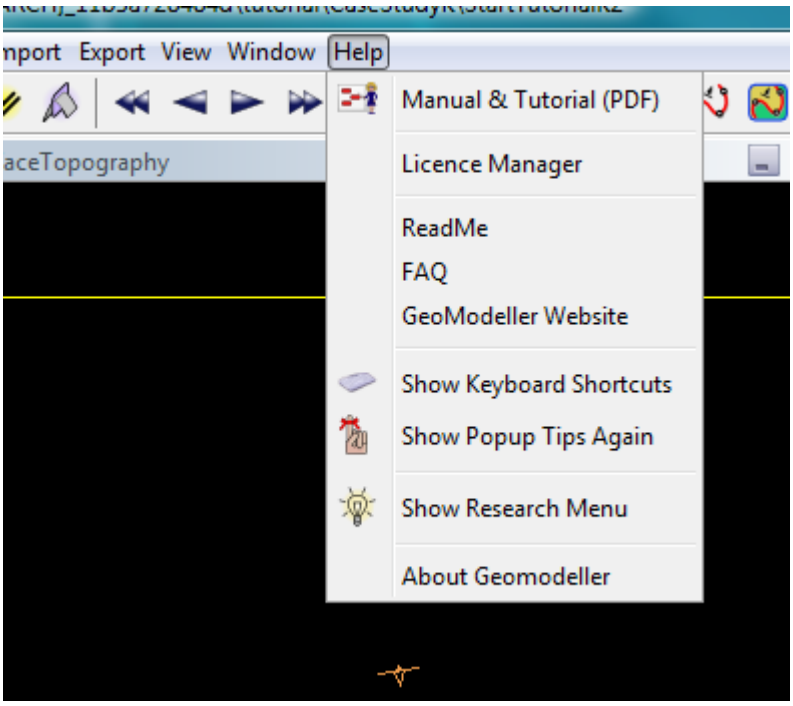
Keep the session open for the next tutorial exercise.

Tutorial K7: Compute Magnetics Solutions

A Beta capability exists in Geomodeller V2012, to estimate the magentic response of the individual "HOT-SPOT" solutions with the press of just one extra button. The option is currently hidden away under the Research Menu, Geophysics, 3D.

The reason for this is that it is relatively new and untested, as well as being a compromise on what will be provided in the near future. The aim is to do a full 3D skeletonized mesh of the dyke , using a new algorithm that assumes an infinetely thin sheet for the planar geometry, and a thickness/susceptibility for the bulk. Tests show this approximation remains very acceptable for even quite thick dykes.

1 The first step is to reveal the Research Menu. Go to the Help item, and click on the Show Reeasech Menu item.



2 In the research menu, go to the Geophysics item, pull right to 3D and then choose

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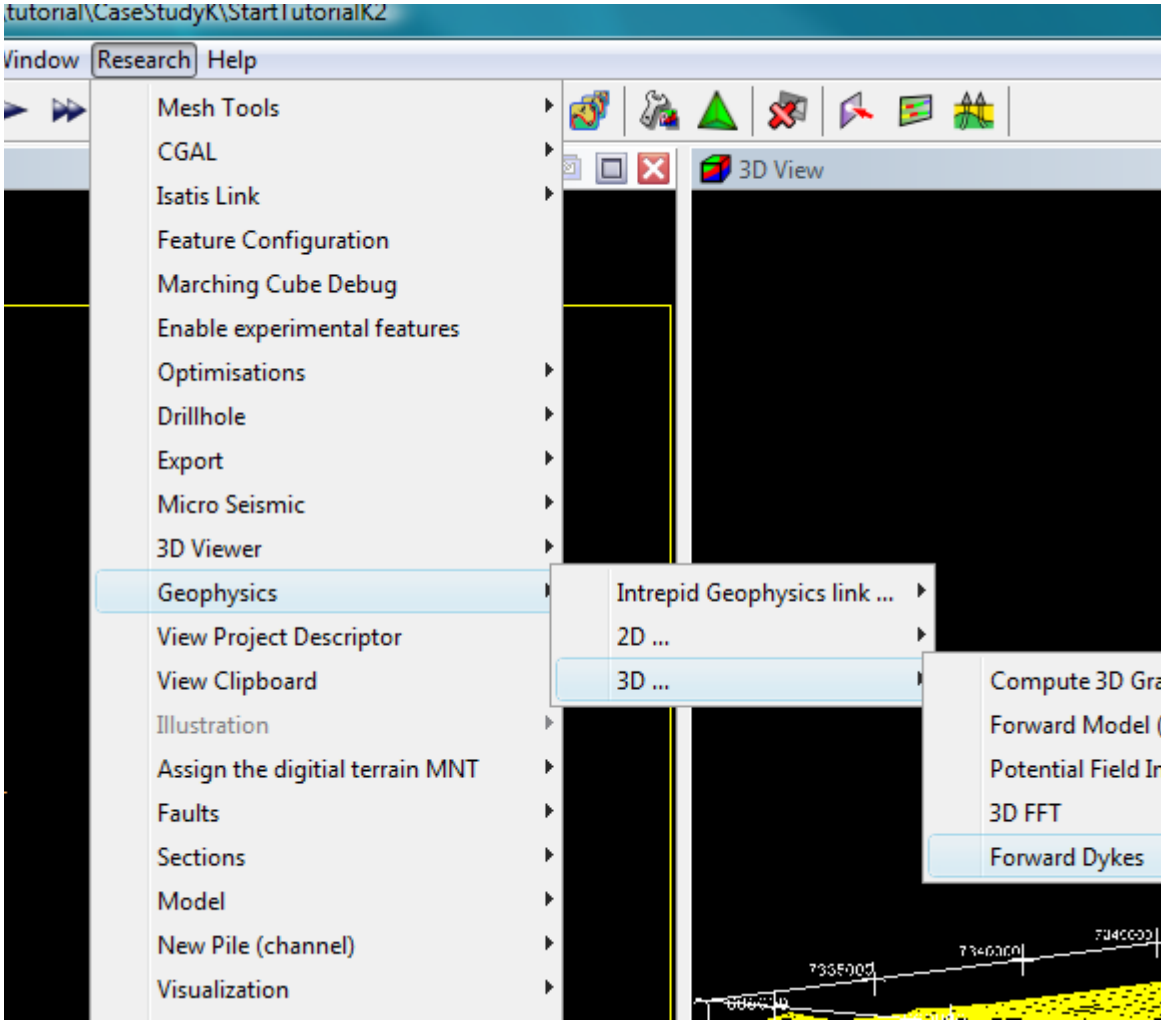
Forward Dyke.



3 At this point, a process that parallels other forward modelling workflows is started. Behind the scenes, Geomodeller makes up a task file and dispatches that to a seperate tool to do the actual work. Examples of the task file and a sample grid are attached. As this task file is assembled and before spawning a sub-process, an automatic “dykecase” subdirectory is created to capture all the inputs and proceeds of this transaction. The magnetic vector is always taken from the currently set IGRF. There is no busy clock or progress bar, so wait a minute or so for the calculation to finish. The screen will repair itself at this point.

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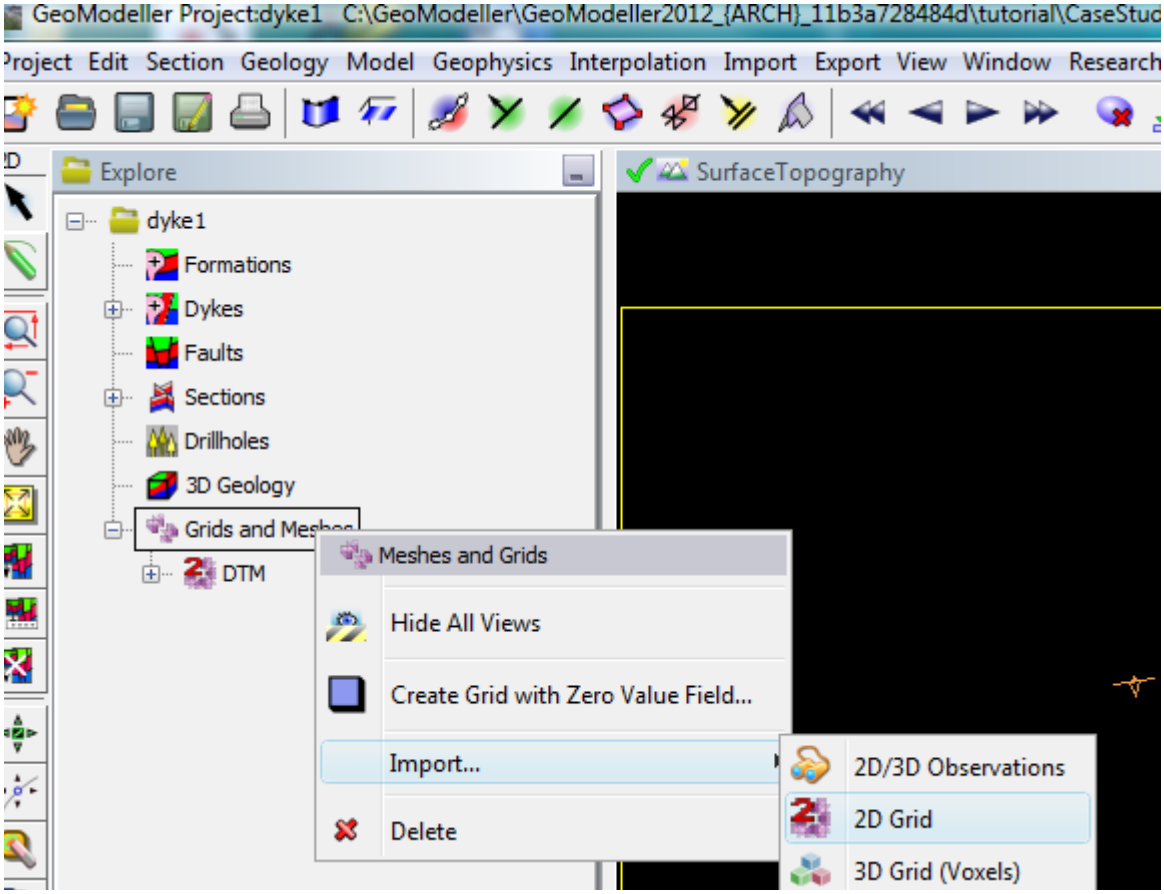
4 To view the result, go to Grids and Meshes in the data explorer tree.



5 Navigate to the current tutorial starting model and then look inside the directory there till you find one that has the title “dykecase” You should choose the

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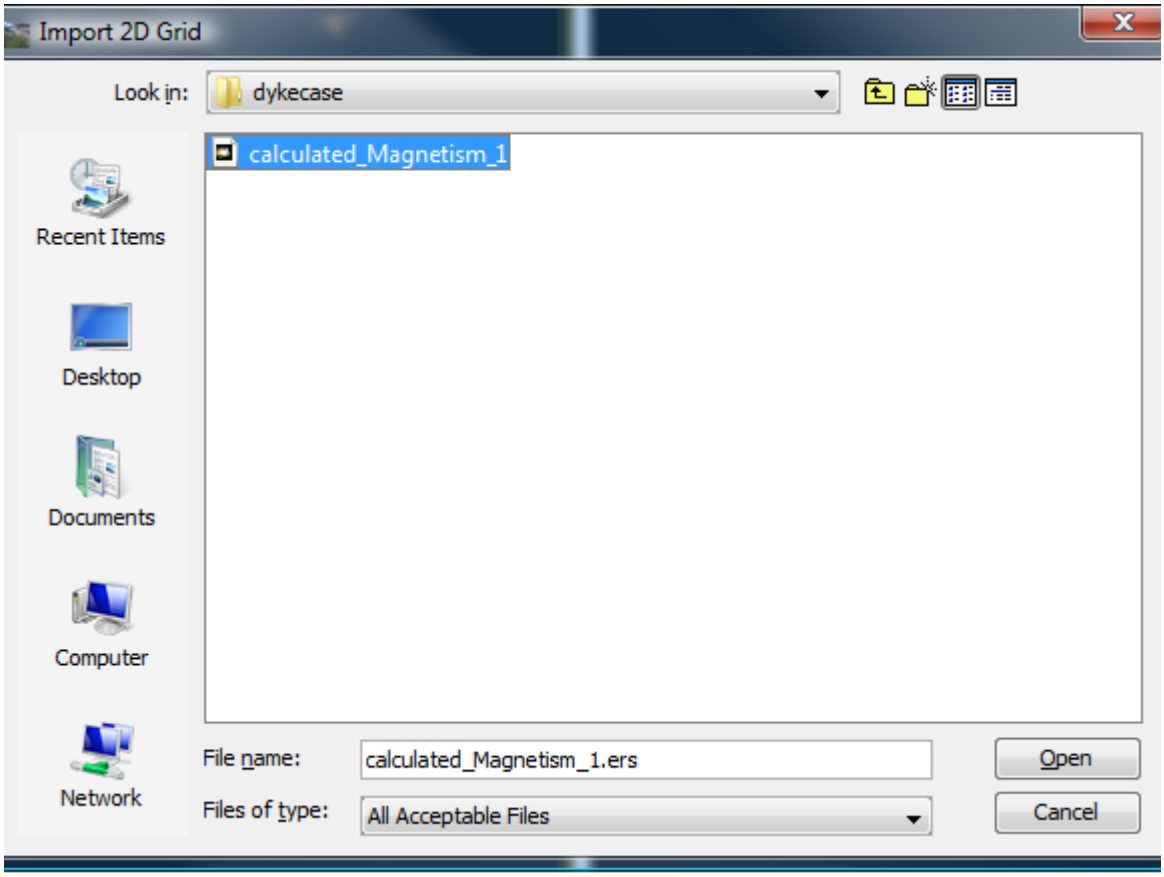
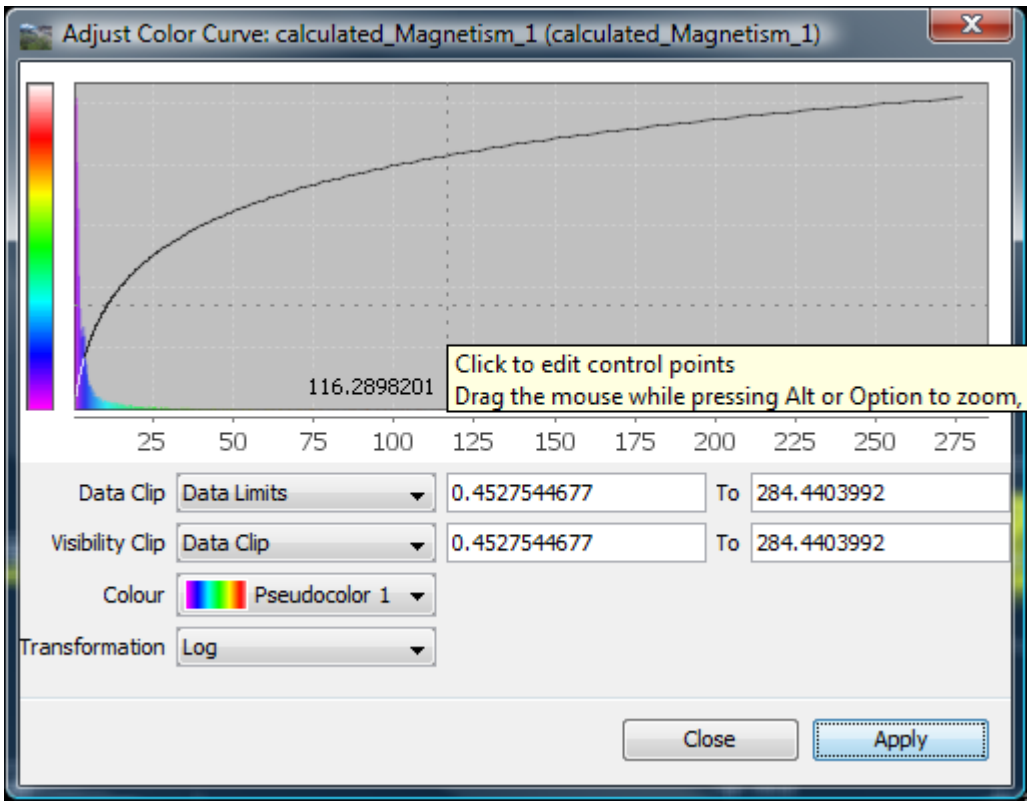
"calculated _magnetism_1.ers" grid.



6 The data needs a colour stretch to show the response to its best effect. Choose a right mouse button > Colour table option. The Log transformation works well.



7 Now examine the effect on the geophysical forward model response grid in the

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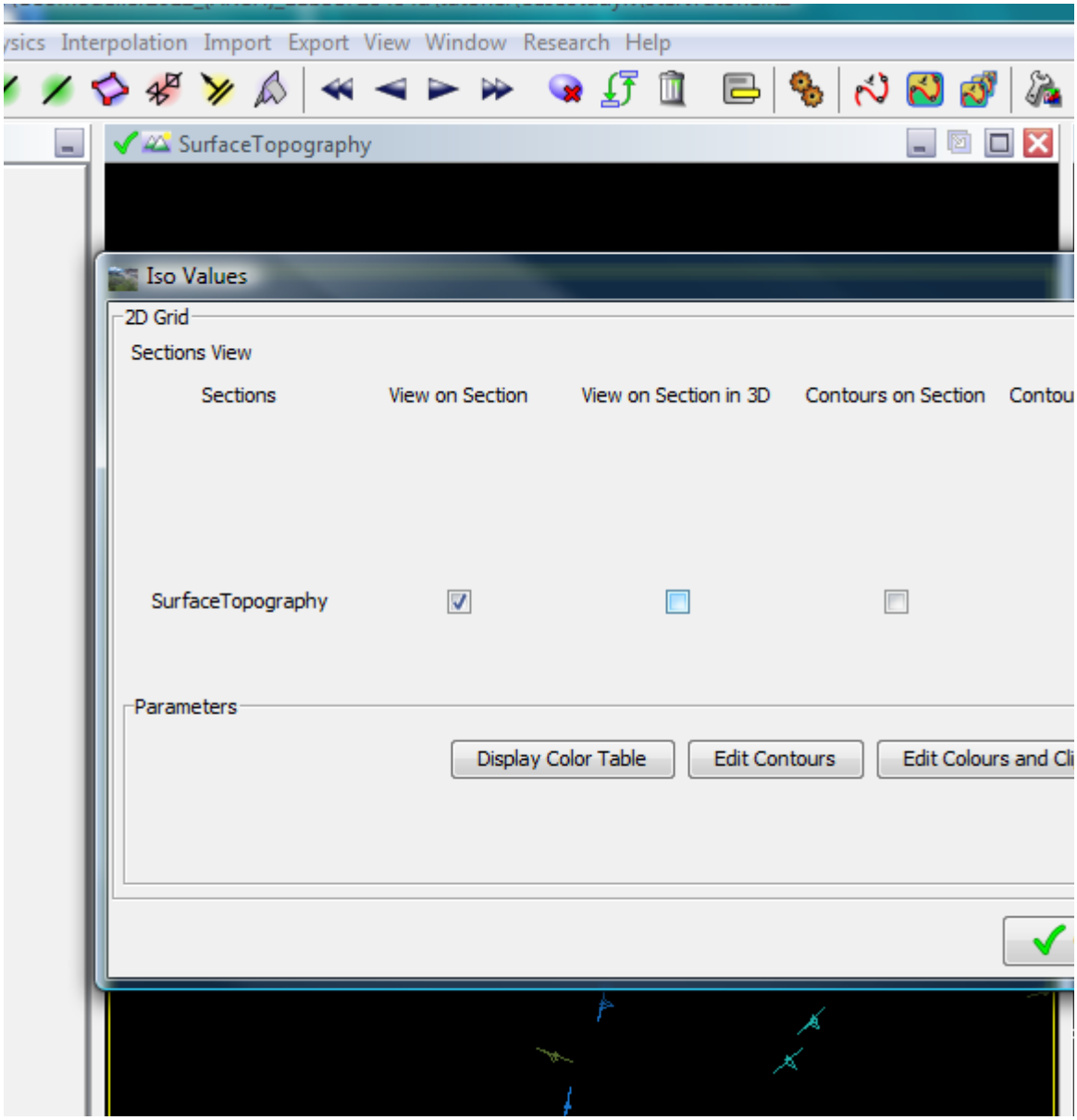
topographic section, by choosing the viewing manager.



8 And now finally, the image itself can be seen in the topography window.

9 All data can be examined outside the Geomodeller environment in the following

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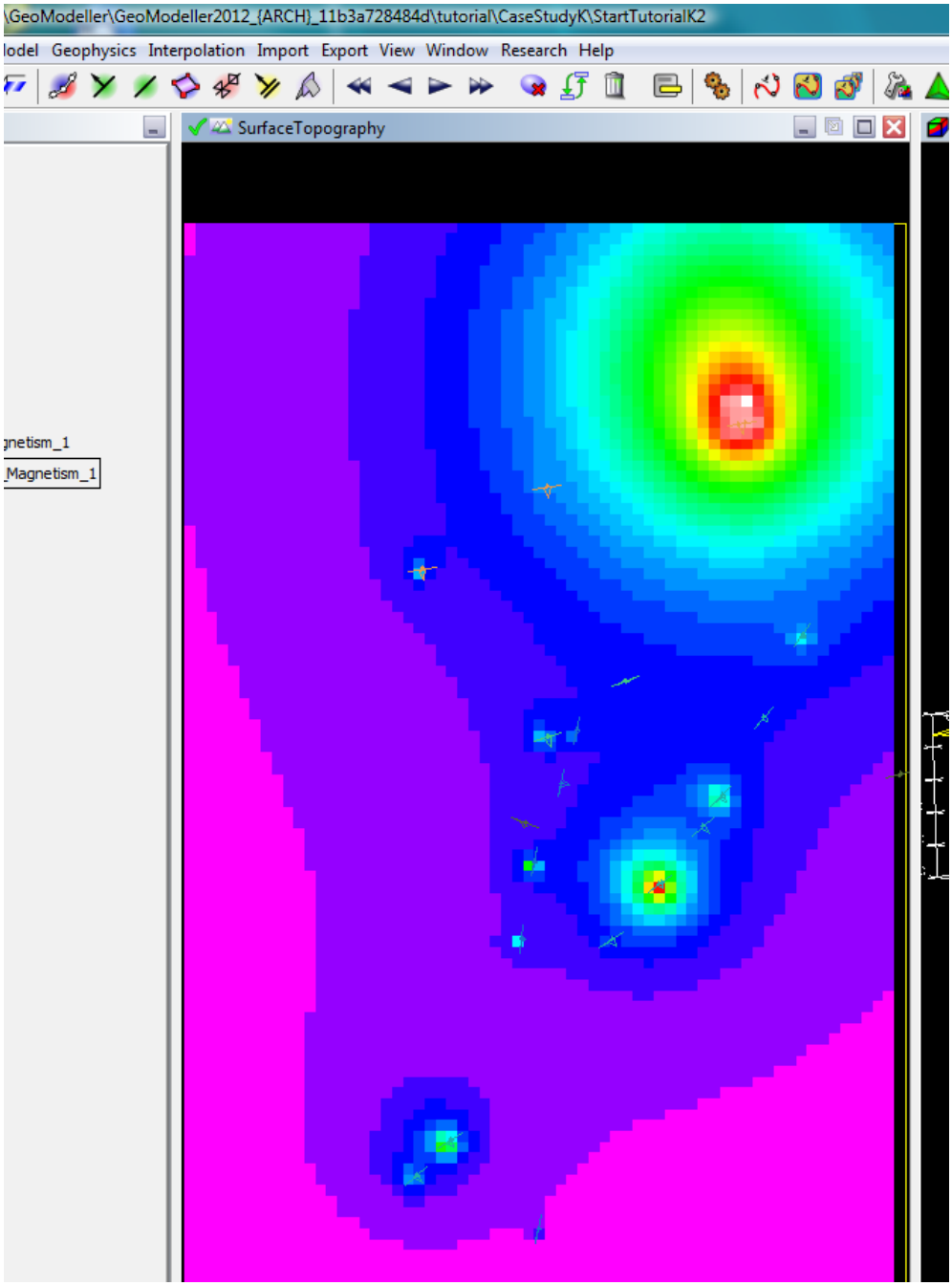
directory "...tutorial\CaseStudyK\StartTutorialK7\dykecase"



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10 This is the end point in the tutorial. Note the dykes are not being modelled in this example as continuous bodies, as the HOT-SPOT representations have been thinned extensively. When a skeleton thin sheet is calculated from the underlying potentials, this will not matter.

11 To get a better result in the meantime, you need to use most of the HOT-SDPOT solutions from profile to profile, so they form continuous detail traces over the extent of the dyke, without leaving big breaks. To do this, you need to start again, perhaps with your own aero-magnetic dataset and the NAUDY tool. Ask Intrepid if you wish to try this more expansive proceedure.

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